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A GENERAL ECOLOGICAL SURVEY OF SOME SHORES IN NORTHERN MOÇAMBIQUE

by

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(Received August, 21, 1958)

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i. INTRODUCTION

The shores of northern Moçambique are well within the tropics, reaching latitude 10° S at the northern limit. Collections of shore animals have been made from time to time and authors of taxonomic studies have frequently pointed out affinities of the fauna with that of the west Pacific. The coast is considered part of the Indo-west-pacific province of Ekman.

Tropical features such as confluent coral reefs, fields of Cymodocea on intertidal flats and zoned mangrove swamps persist as far south as Inhaca Island (latitude 26° S) in Southern Moçambique (KALK, 1954 and 1958, MACNAE and KALK, 1958), as a result of the influence of the warm equatorial waters of the southward flowing Moçambique current. A number of tropical species intrude even into Natal in South Africa for the same reason (STEPHENSON 1944 and 1947, SMITH 1952 and 1953). But in Natal and to a lesser extent at Inhaca the gross facies of the upper levels of the rocky shores are not unlike warm temperate South African shores and might be termed sub-tropical in character. The lower shores at Inhaca have many more tropical species than Natal, but

are not so rich in species nor in individuals as are tropical shores. A general ecological study of the wholly tropical shores of northern Moçambique, promised to be of some interest, and a first survey was carried out therefore, in November 1955.

Moçambique Island (latitude 15° S) at the northern end of the Province was chosen as a base. It has both semi-exposed and completely sheltered shores with rock and sand habitats. At Chakos, the north-east point of Moçambique Bay and at the Isle of Goa some 8 Km. east of Moçambique Island are beaches exposed to the full force of the ocean. These, as well as the typical semi-sheltered shore at Baixa da Pinda (latitude 12° S) at the south-east point of the Bay of Memba, were examined. Sheltered shores in Conducia Bay, Nacala Bay and at Quissimajalo were also inspected. For comparison, additional places in the south of the Province were visited, such as Santa Carolina (latitude 22° S) and the rocky shore of Inhambane (latitude 24° S), where the University of Cape Town Survey had been investigating the estuary. The locations of the places visited are indicated in Fig. 1, which also shows the direction of the ocean currents that are responsible for the nature of the littoral fauna of the southern African coasts.

ii. GENERAL PHYSICAL CONDITIONS OF NORTHERN MOÇAMBIQUE SHORES

The temperature of the air at the meteorological station at Mossaril in Moçambique Bay has a mean minimum of 20.0° C and a mean maximum of 30.6° C with a mean annual temperature over the last 25 yars of 25.3° C. This is 2.5° C higher than at Inhaca and 4.8° higher than at Durban in Natal. Sea temperatures have not been recorded near land, but the range at these latitudes is given as 24° C in August and 28° C in February (Sverdrup, Johnson and Fleming, 1942), a slightly higher mean than that of the air. A record of sea surface temperature at latitude 20° S in the Moçambique Channel by the «William Scoresby» at 18 hours on 4-7-50 was 24.24° C. while the temperature of the air was 23.3° C.

An average of 955 mm. of rain falls in the year, two thirds of it in the summer months (Relatórios dos Observatórios, 1954). The rivers flow only in the summer months, and mangrove lines the greater portion of the sandy sheltered shores. But at Moçambique Island itself (as well as at the Isle of Goa), there is no mangrove; there is no fresh water at all, neither river, spring nor well. There is no evidence that the salinity of the surface water is other than that of the Indian Ocean at this latitude, namely 35.1 parts per thousand (Discovery Report, 1955). As a consequence of lack of river water, the sea is exceptionally clear during the greater part of the year. The coral reef is

reputed in naval circles to be the most clearly visible along the coast of the whole Province. Details were easily seen while snorkeling above the reef in 10 — 15 m. of water.

The tidal range is greater than in South Africa, being 4.0 m. at the northern end of the Province, and the pattern of tides is semi-diurnal and equal (Tâbelas de Mârès, 1955).

There are a number of bays at these latitudes with very sheltered shores. But even those fully exposed to the Indian Ocean are semi-sheltered, since a submerged coral barrier with occasional breaks stretches across the entrance to the bays. Strong wave action is thus exceptional since the force of the waves is lost when they break on the bar. The east shore of Moçambique Island and that of Baixa da Pinda were thus typical of the area.

iii. THE FAUNA ON THE SHORES OF MOÇAMBIQUE ISLAND

Moçambique Island is small (3 x 0.4 km.), but very densely populated. Its fortifications rise sheer from the sea at high tide, but when the tide is low, a sandy beach about 100 m. wide is exposed on the west, and on the east a beach, mostly rocky, about 350 m. wide. The island is almost in the centre of Moçambique Bay (15 x 10 km.) and an outer ring of islands and rocky shoals gives some shelter from the Indian Ocean. Fig. 2 shows the position of the island, the shallows of the bay and the deeper channels along which the breakers travel, meeting north-east of the island. The greatest amount of wave action is thus at the north-east point on the edge of the channel opposite a gap in the bar. There is a well-developed submerged reef about 5 km. distant and a good deal of coral in the shallow water of the bay.

The semi exposed shore

The north-east shore has a vertical drop of 4 m. over a horizontal distance of 350 m. From highwater a fairly steep slope of sand 50 m. long, extends to mean tidal level ending in an interrupted wall of sandstone rock 3 m. high, eroded into little turrets and pinnacles. The remainder of the shore, below mean tidal level, takes the form of two rocky platforms with a shallow step between them at a distance of 250 m. down the shore (Plate I).

The platforms are a patchwork of sand-covered rock and bare rock, so that the communities characteristic of either sand or rock exist here side by side, at all levels on the lower shore. The sand is of varying depths, and accumulations occur in shallow pools or heaped around ridges between the pools. There are little nests of deeper moist sand in hollows or merely thin

layers covering rock. Both sandy and sand-free rock are fully colonised by plants and animals. The distribution of the common animals is shown in Fig. 3.

The supralittoral fringe

In the sandy slope behind the rock barrier at the level of mean high neap tides, the sand mussel, *Donax faba* and the crab, *Ocypode ceratophathlmus,* are present. *Coenobita rugosus,* a land hermit crab is common in *Nerita* shells.

On the rocks at high level, a little black lizard, scampered among the rock crabs, *Grapsus strigosus,* and numerous crested blennies, *Antennablennius bifilium,* leapt from ledge to pool when disturbed. Species of *Nerita* are common, namely *N. plicata, polita, textilis* and *undata*[x]. Periwinkles are uncommon, although *Littorina obesa* and *Tectarius natalensis* were both found. There are many false limpets, *Siphonaria carbo,* in crevices and an unidentified small white conical patellid[x].

The midlittoral

At the foot of the high level rocks on their landward side, is a band of closely packed bivalves *Perna dentifera.* These are asymmetrical, white, black-edged mussels which are present where protection from wave action is afforded, and are also characteristic of the rocks inside the bay. Very few barnacles, and only *Chthamalus dentatus,* were seen above and below the pearl oysters. There are more of them on the seaward sides of the rocks.

The clean golden sand below the rocks is dotted with rings of tentacles protruding from holes. Some were from burrowing edwardsiid anemones others from *Holothuria pervicax* and still others from terebellid worms that could not be extracted whole.

On the raised ridges throughout the length of both platforms, the marine angiosperm, *Diplanthera uninervis* is dominant, growing about 10-15 cm. long. Sandy depressions and pools are overgrown with the flowering plants *Cymodocea serrulata* and *C. rotundata.* Where the sand is not so thick, the brown alga *Padina commersonii* occurs at middle levels. A short mixed algal turf surrounds the rims of pools. *Valonia macrophysa, Colpomenia* sp. *Turbinaria ornata* and a species of *Ulva* spread over rock boulders, and *Halimeda cuneata* or *Hormophysa triquetra* occur in pools. One of the commonest is a siphonous green alga like a ball of string, *Valoniopsis pachynema.*

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[x] Not found at Inhace.

Cymodocea ciliata is confined to the lower platform, i. e. to the infralittoral fringe. In general, the plant population on the shore is predominantly of marine angiosperms, as on a sheltered tropical shore. Algae take a second place, but are by no means rare, probably because there is sufficient wave action to prevent the deposition of silt.

In the small wet pockets of sand, handfuls of the yellow enteropneust, *Ptychodera flava* could be collected. In deeper patches of sand on the lower platform there are occasional mounds formed by the worm casts of a large enteropneust, probably *Balanoglossus studiosorum*.

The most conspicuous animals on the shore are echinoderms. The brittle stars *Ophiocoma valenciae, O. scolopendrina, Placophiothrix venosa* and *Ophiactis modesta*, in pools among the plants, are not hidden from view but very actively feeding and moving. The cucumbers *Holothuria atra, H. leucospilota, H. difficilis* and *Actinopygia mauritiana* are littered about in profusion and sometimes coated with sand, but not burrowing. The sea urchin *Echinometra mathaei* is crowded so densely in pools of all kinds that there is scarcely room to set foot.

Whenever the rock surface is not very sandy, colonies of *Zoanthus sansibaricus* form a thick coat. But other zoanthids were not seen. The rock ridges between the pools are crowded with masses of the asymmetrical bearded mussel, *Modiolus barbatus*, instead of by barnacles as in the south of the province and in Natal. This mussel also packs the vertical face of rock between the two horizontal platforms. Although this species forms part of the diet of the native population and bushels are removed every day of spring tides, the numbers on the rocks and among the *Cymodocea* are incredibly high. The intense decimation of their numbers has no apparent effect.

The lower shore appears to have no barnacle population, except at the nort-east point, where the strong current in the channel sweeps into the bay, and there it is crowded with *Balanus amphitrite var. communis*.

In the shallow pools there is a wealth of tropical animals. The gastropods are those typical of sheltered shores such as *Cerithium caerulem, C. morus* and *C. kochi, Planaxis sulcata, Nerita albicilla* and *Turbo marmoratus*. Lower down the shore Columbellids such as *Columbella fulgurans* [x]. and *C. mendicaria* are common. Many species of crabs such as *Xantho exaratus, Etisus laevimanus, Pilumnus vespitilio* and *P. trichophoroides* were seen.

There are some large coral pools on the first platform containing animals more typical of the lower platform. Both may be considered as an extension of the subtidal on to the shore, an infralittoral fringe.

Coral pools and the coral reef

Large circles of corals enclosing shallow water form pools and the following species were collected: *Pavona frondifera* [x], *Coeloria lamellina* [x], *Pori-*

tes porites[x], *Pocillopora verrucosa, P. damicornis bulbosa, Stylophora pistillata, Montipora venosa* and *Favia favus*. Alcyonacea, very large anemones and sponges (unfortunately not yet identified) are also present. The sea urchins, *Tripneutes gratilla*, and *Prionocidaris pistillaris*[x] accompanied the ubiquitous *Echinometra mathaei;* species of *Holothuria, Stichopus chloronatus* and the starfishes *Linckia multifora, Culcita schmideliana, Nardoa variolata*[x], *Protoreaster linckii* and *Asterina burtoni* are common. Ophiuroids are very numerous including a number of Ophiodermids as well ás Ophiocomids and Ophiotrichids.

The associates of the coral were not extensively studied, but conspicuous animals were collected. The usual coral crabs such as *Trapezia cymodoce* and *T. guttata* were common as well as other xanthid species such as *Chlorodopsis areolata*[x], *Hypocolpus diverticulatus*[x], *Libya plumosa* (which carries a tiny anemone in each chela) and *Lissocarcinus orbicularis* (which is associated with *Holothuria atra*). The spider crabs *Dehaanius 4-dentatus* and *Elamena mathaei, Menaethius monoceros* were known from the south, and *Micippe philyra*[x], and *Pseudomicippe nodosa*[x] were new records.

Some Polychaeta were taken from the dead bases of corals, loose rocks and algal turf around the edges of pools. Two thirds of them proved to be similar to the species found with coral debris and with the sandy worm tubes of *Idanthyrsus pennatus* in the south. Six species including the plume worms *Fabricia mossambica*[x] and *Chone collaris*[x] had not been found further south. The sipunculid *Physcosoma stephensoni* was as common as in Natal.

A description of a tropical shore cannot ignore the fish population, since the numbers of species and of individuals make them a conspicuous section of the shore community. Eels are numerous and active, travelling from pool to pool when disturbed. The only ones caught were *Echidna nebulosa, Siderea picta* and *Ariosoma anago*[x]. The gobies *G. albomaculatus*[x], *G. nebulosus, G. capistratus* and *Bathygobius fuscus*, the blennies *Halmablennius dussumieri, Omobranchus striatus* and the blenny-like *Enneapterygius obtusirostre*[x] were collected. Numerous coral fishes belonging to the genera *Abudefduf, Amphiprion* and *Chaetodon*, and various labrids and tobies typical of coral reefs were seen.

Submerged coral growing in 1-10 m. of water was observed at various points north-east of the island nearer the mainland, to see whether there were any major differences from the coral reef at the end of its range in the south, that had not been revealed in the infralittoral fringe of coral pools. Several were noted:

The dominant coral over large areas is *Galaxea clavus*[x]. Colonies grow 5—10 m. high in impressive solid pillars constructed of cylindrical pipes about 10 cm. in diameter. The polyps were visible and their colour cast a brick-red glow over the reef. This species had not been found in the Inhaca reef.

Several species of the more delicate genus *Acropora* were taken: *A. arcuata, loripes, thurstoni, listeri, quelchi* and *decipiens*. There is a rich growth of

the stinging hydroid coral, *Millepora alcicornis*[x] in which the little barnacle *Pyrgoma milleporae*[x] is embedded. There are no fire corals in the southern reefs. Additional species of *Pocillopora* are present: *P. setchelli*[x] and *P. modumanensis*[x], and *Seriatopora verrucosa*[x]. There are large plates of *Turbinaria* arranged like a giant lettuce, rippling mounds of *Montipora* and solitary slabs of the large fungid *Herpolitha limax*[x]. All of these genera are similar to those recorded in the coral reefs of the New Hebrides (BAKER, 1925) and the Great Barrier Reef Islands (STEPHENSON, STEPHENSON, SPENDER and TANDY, 1931), but very few of the species are common to the west and east Pacific Ocean.

The associates seen on the shore in coral pools are characteristic of the fully developed subtidal reef: giant anemones, green and white alcyonaceans, and in addition there are port-wine coloured gorgonids, huge fan-like sponges and tridacnid clams. Echinoderms are not conspicuous and it was not possible to investigate the coral fishes or smaller associates.

The sheltered shore

The west shore of Mocambique Island facing the bay is still more sheltered than the east. Vertical rocks form a cliff above high tide down to mean tidal level. The rest of the shore consists of gently sloping sand flats, leading down to the channel.

On the rocks the main difference from the east side is the presence of scattered oysters, *Crassostrea cucullata* below the *Perna dentifera* belt. Among loose stones at midtidal level, the serpulid worm, *Pomatoleios kraussi*, which forms a dense belt in Natal, occurs as isolated calcareous tubes. Beneath the stones were many brittlestars such as *Ophiocoma scolopendrina* and *O. valenciae*, the sea-cucumbers *Holothuria hilla* and *H. erinaceus*[x], two tropical plume worms *Fabricia mossambica*[x] and *Chone collaris*[x], and some terebellid species *Thelepus setosus*[x] and *Terebella ehrenbergi*[x].

The dominant worm is *Mesochaetopterus minutus* whose colonies of sandy tubes form large hillocks. The usual scavenger gastropods of sand flats such as species of *Nassarius*, *Natica* and *Polynices* roam the surface and their shells are often inhabited by hermit crabs such as *Clibanarius longitarsus*, *C. padavensis* and *C. virescens*, *Diogenes senex* and *D. avarus*. The burrowing brittle star *Amphioplus integer*, the sipunculid *Siphonosoma cumanensis*, eels, gobies and burrowing anemones were frequent. Burrowing polychaetes were abundant in the sand.

A striking feature of the middle shore is a patch of rock just below mean tidal level which was covered with a brilliant green *Ulva*-like alga. Marine angiosperms covered the lower shore and division into zones was just recognisable, since they were compressed into about 50 m. of shore. *Diplanthera uninervis* soon gave place to an association of *Cymodocea serrulata* and *C. rotundata* and within a few metres *C. ciliata* was dominant.

The dominant animal on the lower shore is a large *Balanoglossus* (*studiosorun ?*) and numbers of the pink enteropneust *Willeyia delagoae* (*?*) were also found. Cucumbers and sea urchins similar to those on the east shore were plentiful.

Among the Cymodocea weed, fungid corals such as *Fungia costulata*[x] and *F. cyclolites*[x], red and green alcyonaceans, burrowing anemones and small corals (usually *Pocillopora* spp.) are abundant. The hammershell *Malleus legumen*[x] and the bivalve *Circe pectinata* occur very frequently.

Deserving of special mention is the little spider crab *Cyphocarcinus capreolus*, wich is compressed like a shrimp; it carries a twig of *Cymodocea* on its rostrum. This has been collected at Inhaca, but not otherwise recorded south of the Red Sea. Another spider crab, *Eumedomus granulatum*, and the brittle star, *Ophiothela beauforti*, were found on the sea urchin, *Eucidaris metularia*.

iv. STRONG WAVE ACTION ON THE ISLE OF GOA AND AT CHAKOS

The Isle of Goa with its lighthouse near the entrance to Moçambique Bay, is 8 km. east of Moçambique Island. Waves break on the shores and are almost 3 m. high, so that the effect of exposure to wave action could be seen in very definite form. It could well be assumed that the fauna there would be typical of the few really exposed rocks that exist at these latitudes.

The vertical cliff on the south-east was rather shaded during the heat of the day. Hundreds of the large yellow *Grapsus maculatus* were seen, confirming that it is the grapsid of exposed tropical shores. Chitons 10 cm. long with spiny girdle, *Acanthopleura brevispina*[x], and *Oncidium*[x] sp. of similar size were common, *Nerita* spp. were the only gastropods at high level and periwinkles were rare, even on the rockfaces more sheltered from the waves.

There were no oysters and no band of bivalves, but a large pink barnacle, a *Tetraclita* species was dotted on the vertical cliff, and on the horizontal platform to some extent. *Thais intermedia* and *T. mancinella*, *Cellana capensis* and *Siphonaria oculus* were present but infrequent, but small anemones were found in every crevice. The blue *Eriphia scabricula*[x] was the commonest crab.

The flat platform on the midlittoral was rather bare of animals, but covered with a closely-knit green algal growth. There was no *Cymodocea* (characteristic of sheltered shores) to be seen. At the lower lewels there were communities of red and brown algae including articulated corallines. Under loose stones there were colonial tunicates such as *Aplidium* spp. *Polyclinum macrophyllum*[x], *Didemnopsis sansibaricum*[x] and *Didemnum psammatodes*[x].

Sponge coated the edges of pools. Brown zoanthids were present but did not occupy large enough areas to form a belt.

The lower levels of the shore were populated with coral species forming isolated colonies or pools just as on Moçambique Island. The extent of this fringe was lessened by the configuration of the rock which fell away into deep water at low spring tide.

v. SHELTERED SHORES IN NORTHERN MOCAMBIQUE

The small rivers of northern Moçambique wend their way to the sea through flat land covered with dense mangrove. A typical estuary then broadens out into extensive *Cymodocea* covered flats making a wide sheltered bay with a narrow channel down the centre. The entrance to the bay is for the most part barred by submerged coral. Even when the rivers are dry, tidal water extends many miles inland up small channels in the mangrove. From the air the colour of the trees enables one to pick out the course of these channels and to detect a distribution pattern which one cannot easily distinguish on foot, for the density of the vegetation hinders investigation. *Rhizophora mucronata*, with its darker leaves, lines the banks of the channels, and the lighter yellower *Ceriops tagal* occurs on the drier parts of the swamp. *Avicennia marina*, the pioneer, is taller and fringes both the seaward edge, mixed with *Sonneratia alba*, and the older inland parts. *Bruguiera cylindrica* indicates wetter pockets. On the inland edges of the swamps there are large bare sand flats only flooded at spring tides, not yet colonised by trees nor by halophytes.

From what has been seen of the mangroves at Lumbo and Mossaril in Moçambique Bay and at Geba near the Bay of Memba, the animals and plants follow a similar zonation pattern to that described for the Inhaca mangrove (Macnae & Kalk, 1958). Though the species are different, the zonation is similar to that in the Batavian mangroves (Verwey, 1932) and the Malayan swamps (Watson, 1928).

The landward fringe is populated by the grapsid, *Sesarma*, the hermit crab *Coenobita* and the land crab *Cardisoma carnifex*. The bare flats at the level of high spring tides support only *Uca inversa*, the biggest of the fiddler crabs. Avicennia fringes give sufficient shade and water for *Uca annulipes* and *U. chlorophthalmus*. The wetter interior of the swamp is riddled with burrows of different species of *Sesarma* and *Uca* and the banks of the channels populated by the mud-skiping goby, *Periophthalmus*. The mangrove molluscs *Pyrazus palustris, Cerithidium decollata* and *Cassidula labrella* and the sheltered shore periwinkle *Littorina scabra* are common.

The bays visited departed from the general plan mentioned above according to the gradient of the shores. The periphery of Conducia Bay near Saua Saua, where a clear fresh spring comes to the surface above high tide level has, on a distinct slope, only a narrow fringe of mangrove consisting entirely of *Avicennia* with *Uca annulipes*. The greater part of the flats lies just below mean tidal level and is composed of fairly clean sand occupied by thousands of *Dotilla fenestrata*, a soldier crab, which makes only temporary dugouts and follows the tide down and back again, feeding on the way. They select food from the sand and reject little round fuzzy balls of sand that form a loose crumby surface layer. The *Cymodocea* areas are narrow and confined to the banks of a deep channel in the centre.

At Quissemajalou near Nacala, the estuary has steep banks at high level and the greater part of the flats are towards low tide level; they are covered with *Cymodocea serrulata* and *C. rotundata*. The brittle star *Ophiocoma valenciae* had a density of around 50 per sq. m., and the tips of their outstretched arms touched their fellows. Many large green anemones, *Stoichactis* sp. with commensal fishes and prawns were anchored in the sand.

In Nacala Bay, rocks occur at high level and the gradient of the sandy shore was steep. There, *Cymodocea ciliata* is the chief species and it grows luxuriantly reaching over a metre high. Snake-like orange and spotted synaptids poise gracefully among the weed, licking the hydroids from the leaves with their tentacles in a leisurely way. On the rocks a sheltered-shore grapsid, *Metopograpsus oceanicus*[x], was taken. After a few metres of *Cymodocea ciliata*, the bottom drops suddenly to 27 m. deep.

In general, the distribution of the common animals and plants in the sheltered bays was like the west shores of both Moçambique Island and Inhaca Island. The relative proportions of the communities or organisms depended on the gradient of the shore, which in turn is a function of the size of the river and the tidal movements in the estuary.

vi. ECOLOGICAL PATTERNS ON THE SHORES OF SOUTHERN MOÇAMBIQUE

The coast of Sul do Save is characterised by a series of north pointing spits of land enclosing bays where small rivers enter the sea. The most southernly is the Inhaca peninsula; 200 km. further north a smaller replica occurs at Inhambane. Near Vilancoulos 300 km. to the north, the spit continues northwards as a series of low islands in the same line, forming the Bazaruto group including Ilha da Santa Carolina. Rocky headlands are exposed to wave action at the points of these land spits and otherwise the whole coast is a protected gentle sandy slope, since it is sheltered by an offshore submerged coral barrier.

The fauna of the rocks at Cabo Inhaca have been described in some detail (KALK, 1958). At Inhambane there is a similar cliff with wave cut terraces some of which are immersed at high tide and in some places there are two intertidal platforms. The plant and animal zonation does not differ from that on the exposed coast at Cabo Inhaca and at Ponta Abril on the Inhaca Peninsula.

It may be described briefly as being divided into a number of fairly clearly defined belts:

1. A supralittoral fringe extending above mean high spring tide level for 2 or 3 metres as a result of the splash and spray of waves, where the periwinkle *Tectarius natalensis* is abundant and above it *Littorina obesa* is common. Individuals of tropical species of *Nerita* are present.

2. The upper midlittoral on the cliff face is plastered with the tiny barnacle *Chthamalus dentatus* among which the large pink barnacle *Tetraclita serrata* occurs in large numbers. The oyster *Crassostrea cucullata* forms a distinct belt below. At Inhambane in rock crevices there are conspicuous clusters of the bivalve *Perna dentifera* which at Inhaca was less obvious and small in size. *Siphonaria oculus* and *S. dayi* and some *S. carbo* are frequent over the base of the cliff.

3. The lower midlittoral zone commences with large colonies of the vermetid mollusc, *Novastoa* sp. followed by a carpet of algal turf which is interrupted only by large sheets of zoanthids such as *Palythoa nelliae* and *Zoanthus zanzibaricus* among which are many sandy tubes of the polychaete, *Mesochaetopterus minutus*. Lower down the shore boulders are encrusted with sandy tubes made by the Sabellariid worm, *Idanthyrsus pennatus*. The tubes are inhabited by a host of commensals very similar to those associated with coral. Among the algae, some limpets, *Patella barbara*, may be found.

4. The infralittoral fringe is occupied partly by pure communities of smaller brown or red algae, partly by *Cymodocea ciliata* and to some extent by the tunicate *Pyura stolonifera*, which is particularly abundant under overhangs.

5. Coral is found only occasionally as isolated heads on the lower shore, but infratidally confluent fields of coral exist as at Inhaca.

The sheltered shores of Sul do Save are usually sandy. Sheltered rock has only been seen at Ilha da Inhaca and Ilha da Santa Carolina although

it is present at Xai Xai, for example, and some parts of the Inhambane estuary and, no doubt, other places not visited. Where the slope is very gentle and there is some influence from fresh water either as seepage as at Inhaca or from rivers as at Machangulo, Inhambane and the mouths of other rivers, the shores above mid-tidal level are occupied by mangrove. Otherwise gentle sandy slopes are found lapped by small waves. The lower parts of the shores are always occupied by belts of marine angiosperms.

In the extreme south of the colony at Inhaca Island the sheltered rocks are coated with the *Chthamalus dentatus* and *C. assostrea cucullata* on the upper shore. Periwinkles are far fewer, *L. africana* is rare and *Tetraclita serrata* apparently absent.

At midtidal level and on the lower shore wherever silt is not deposited, as for example on living coral bases, *Balanus amphitrite* var. *communis* is the chief barnacle. *Septifer bilocularis* is the commonest bivalve and the coral debris supports a medley of reef associates including a number of colonial tunicates, molluscs, xanthid crabs, sea cucumbers and brittle stars. Where rock offers a suitable substratum on the banks of deep channels with swiftly flowing tidal currents, a confluent reef occupies the infralittoral fringe and spreads to the infralittoral zone.

At Santa Carolina (latitude 21° 30' S), the rocky shores already have a more tropical appearance even at high levels. *Littorina africana* was not found and presumed to be absent. *Siphonaria carbo* which commences its range at Inhaca is very common and *S. capensis* was not found. *Acanthopleura*, the tropical chiton was present. *Crassostrea* was infrequent and *Melina dentifera* a little more common than at Inhambane. *Septifer bilocularis* was still present as well as colonies of the blue Vermetid, *Novastoa* sp. A white shelled Vermetid present as isolated individuals at Inhaca forms dense colonial masses. *Patella barbara* was not seen. The lower shore on the east coast consists of a flat platform with masses of coral debris and coral pools, while the west coast consists of fields of Cymodocea.

When the sheltered shores are sandy at high levels the slopes are inhabited by the crab *Ocypode* and bivalve *Donax*. In the more sheltered areas *O. ceratophthalmus* and *D. faba* are the species; when wave action is a little stronger, *O. kuhli* and *D. incarnata* and perhaps other species of *Donax* are found. Land hermit crabs, *Coenobita cavipes* and *C. rugosus* occur above high tide mark.

The mangroves in the south differ from those in the subtropical bays and estuaries of Natal which have been described for St. Lucia Bay (Day, Millard Broekhuysen, 1953), for Richards Bay (Millard and Harrison, 1954) and Durban Bay (Day and Morgans, 1956), in that the zonation pattern of the trees and crabs is more fully developed. The pattern of the trees is similar to that of Kenya and Tanganyika (Graham, 1929, Walter H. and Steiner, 1937) apart from the absence of *Sonneratia alba* which occurs only further north.

Avicennia marina grows on both seaward and landward fringes of the mangrove swamp. *Rhizophora mucronata* lines the waterways, with *Ceriops tagal* and *Bruguiera cylindrica* mingled in a dense central thicket. Grapsid and Ocypodid crabs follow the topographical pattern from dry to wet in the order *Uca. inversa, U. annulipes, U. chlorophthalmus, U. urvillei* and *U. marionis* for fiddler crabs and the order *Sesarma eulimene* and *S. meinerti, S. guttata* and *S. catenata, S. longipes,* and *Ilyograpsus rhizophorae* for grapsids.

The lower parts of the sandy shore from midtide to the infratidal are covered with fields of marine angiosperms. The first belt is dominated by *Diplanthera uninervis* with which a little *Halophila ovalis* is mixed. It extends to the level of average low tide, giving way without a gap to an association of *Cymodocea serrulata* and *C. rotundata.* Below mean low springs *Cymodocea ciliata* or *Thalassia hemprichi* occur and with it may be mixed *Syringodium isoetifolium,* with its distinctive slender cylindrically rolled leaves.

There is sometimes a wet muddy «tubicolous worm zone» above the angiosperm belts where *Phyllochaetopteurus elioti* is the dominant worm and *Macrophthalmus grandidieri* the dominant crab. This is a distinctive feature on the west coast of Inhaca Island. Drier patches of sand are dominated by *Dotilla fenestrata* at middle and lower levels. Sometimes large clean sand banks on the lower shore support an association of *Astropecten* and *Echinodiscus* with some pennatulids and alcyonaceans, while muddier sand banks are the homes of large numbers of bivalves.

The most conspicuous animals among the Cymodocea are echinoderms, and worm casts of *Balanoglossus* are dotted about in great numbers. The infauna is rich and varied.

vii. DISCUSSION

Shores *fully exposed to wave action* are few in northern Moçambique because waves break offshore on the coral barrier. Where they do exist they differ from southern exposed shores at Inhambane and Inhaca in the following points:

The *supralittoral fringe* in the north has very few or no littorinids, but many more individuals and one more species of *Nerita.* The chiton *Acanthopleura brevispinna,* is numerous and was traced as far south as Santa Carolina (latitude 22° S).

In the *upper midlittoral* the common large pink barnacle is probably a different species of *Tetraclita; Chthamalus dentatus* appears to be absent. The oyster belt of the south is lacking and *Siphonaria* spp. did not form a distinct association on the horizontal rocks of the middle shore, but were sparse and

scattered. There was no *Novastoa* belt. This Vermetid belt is probably a sub-tropical feature.

In the *lower midlittoral* an algal turf is not conspicuous. Few zoanthids are present, but anemones occur in crevices. Provinces of the sandy worm tubes of *Idanthyrsus pennatus* are present only when the sand for their construction is available.

The absence of the sandy worm tubes of *Idanthyrsus pennatus* which were such a conspicuous feature of the lower shore on the exposed coats of Inhaca and again at Inhambane was striking. It was probably due to the absence of the required sand grains on a shore wholly made of smooth rock. There was no intervening sand slope between the rock platforms and the steep cliff on the Isle of Goa. This Sabellariid worm is found on tropical rocks where there is a coarse sand slope, as for example at Chakos, the northernmost tip of the bay of Moçambique. There the usual wide band of sandy tubes was found under an overhang just below middle tidal levels. There were few living worms on the surface and the thickness of the colony was about 30 cm.; it was very strongly cemented together. On the other hand, the *Novastoa (Vermetus)* belt seems peculiar to Inhaca and Inhambane in the south. Coral intrudes from below and becomes more important than algae at lower levels. The tunicate *Pyura stolonifera* (characteristic of warm temperate shore) was not seen, but colonial tunicates are a feature of crevices and the cryptofauna.

The *infralittoral fringe* is dominated by coral. Of the 25 coral species collected, 7 had not been found further south.

Where the shores are *sheltered* and sandy and there is fresh water influence, mangroves of the same pattern and with similar populations of crabs and molluscs as in the south of the colony grow extensively. There is at least one additional species of mangrove tree and possibly more crabs. The fields of *Cymodocea* in the sheltered bays are like those in the south and gastropod molluscs, hermit crabs and polychaetes are similar. There are, however, many more species of echinoderms, coelenterates and bivalve molluscs and these occur in much greater profusion. There are some different species of polychaetes, and the midtidal zone dominated by *Phyllochaetopterus elioti* as at Inhaca was not seen. The main zonation pattern is otherwise not altered.

On the more typical *partly-sheltered shores* with a patchwork of sand and rock, there are features in common with both exposed and sheltered shores in the south. But there are two important changes in dominant animals that form belts on parts of the upper and middle levels of the shore.

An association of pearl oyster, *Perna dentifera*, has taken the place of the oyster, *Crassostrea cucullata* so characteristic of both exposed and sheltered rocks on subtropical shores. This bivalve occurs as very few small individuals at Inhaca and becomes larger and more numerous at Inhambane; while in the

north it is a dominant animal on the *upper midlittoral* rocks. The dominant bivalve on the rocks of the *middle shore* is *Modiolus barbatus* while *Septifer bilocularis* is characteristic of sheltered subtropical rocks and *Mytilus perna* of the exposed warm-temperate rocks. *Modiolus* is also abundant on the surface of sand amidst Cymodocea or algae.

On the *lower shores*, the algal turf and zoanthids, conspicuous in the south, alternate with patches of marine angiosperm, which were restricted to pools and to the infralittoral fringe on the exposed southern shores. Nereid and polynoid worms inhabit the turf and echinoderms dominate the Cymodocea. Corals are more conspicuous on the lower shore, and their associates which are cryptic in habit amongst coral debris at Inhaca, are abundant in pools formed by rings of corals.

The extent of the coral in the infralittoral fringe and in the infralittoral is much greater in the north; there are more species and more tropical associates occur with them.

The appendix lists species that were collected on the shorês of northern Moçambique. This sample of the fauna includes 74 species not present at Inhaca Island, which is 25% of the total. At Inhaca Island about 15% of its total list of identified animals (about 1,000) was not tropical in distribution. These species have now dropped out or become rare and the fauna is entirely tropical in the north of Moçambique.

In the south of the Province, the Moçambique current and the shallow standing water in coves are warmer than the air. The warmer effect of the sea temperatures is felt longer on the lower levels of the shores which are longer immersed. The upper and middle rock levels reveal the effect of the cooler air by the subtropical nature of the fauna, while that in sand is kept at a more constant temperature and is fully tropical even in the south of the Province.

It appears that in northern Moçambique the temperatures of both air and water are high enough for full development of tropical associations on upper and lower levels of the exposed and sheltered shores.

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Animals from the Tropical Shores of Northern Moçambique

Rock	Sand
Coelenterates (38)	
Acropora arcuata (Brook)	ˣFungia costulata Döder lein
A. decipiens (Brook)	ˣF. cyclolites Lam.
A. listeri (Brook)	ˣHerpetholitha limax Esper.
ˣA. loripes (Brook)	
A. quelchi (Dana)	
ˣA. thurstoni (Brook)	
Favia favus (Oken.)	
ˣGalaxea clava Dana.	
Goniastraea halicora (Ehrb.)	
ˣGoniopora sp.	
Meandrina lamellina (Ehrb.)	
ˣMillepora alcicornis L.	
ˣMontipora ramosa (Bernard)	
M. venosa (Ehrb.)	
Pavona frondifera (Lam.)	
Pocillopora damicornis bulbosa (Ehrb.)	
ˣP. modumanensis Vaughan	
ˣP. setchelli Hofmeister	
P. verrucosa (Ellis & Sol.)	
Porites porites Pallas	
ˣSeriatopora histrix Dana	
Siderastraea sideraea (Ellis & Sol.)	
Stylophora pistillata Esper.	
Alcyonacea spp. M. 71/55, 72/55.	Alcyonacea spp. M. 29/55, 39/55
Anemone sp. M. 59/55	Cerianthus sp. cf. In. 17/55
Gorgonid sp. cf. In. 90/56	ˣGorgonid M. 73/55
Microspicularia sphaeroma (?)	Stoichactis sp. cf. In. 11/55
Zoanthus natalensis Carlgren	
ˣZoanthid sp. M. 70/55 (Purple)	
Zoanthus sansibaricus Carlgren	

ˣ Not found at Inhaca.

Rock	Sand
Polychaeta (35)	
Allmaniella inhacae (Day)	Arabella mutans (Chamberlin)
[x]Amphionome rostrata Pallas	Armandia longicaudata (Caullery)
Eunice afra. var. punctata Peters	Audouinia tentaculata (Mont.)
E. australis Quatref.	[x]Axiothella quadrimaculata Aug.
[x]Filograna implexa Berkeley	[x]Chone collaris Langerhans
Harmothoe dictyophora Gr.	[x]Clymene mossambica Day
Hydroides monoceros (Grav.)	[x]Fabricia mossambica Day
Idanthyrsus pennatus Peters	Hyboscolex longiseta Schm.
[x]Lepidonotus (Thormora) jukesi Baird.	Lumbrinereis papillifera Fauvel
L. purpureus Potts	Magelona cincta Ehlers
[x]Lumbrinereis heteropoda Marenz	Mesochaetopterus minutus Potts
Lysidice collaris Gr.	Scoloplos madagascariensis Fauvel
Nereis falcaria (Willey)	
[x]Opisthosyllis laevis Day	
[x]Perinereis nigropunctata Horst	
Phyllodoce (Sphaerodoce) quadraticeps Gr.	
Polymnia nebulosa (Mont.)	
Pomatoleios kraussi (Baird)	
Pseudonereis variegata (Gr.)	
Spirobranchus giganteus Pallas	
[x]Terebella ehrenbergi Gr.	
[x]Thelepus setosus Quatref.	
Trypanosyllis zebra Gr.	
Mollusca (65)	
[x]Acanthopleura brevispinna (Sowerby)	Anadara natalensis (Krauss)
[x]Beguina variegata (?)	Atrina spp.
Gastrochaena dubia Penn.	Cardium burnupi Sow.
Lithodomus lithophaga L.	Circe pectinata L.
Modiolus barbatus L.	Codakia exasperata Rve.
Perna dentifera (Kr.)	Donax faba Gm.
Pinctada capensis (Sowerby)	D. incarnata Gm.
Tridacna squamosa Lam.	Malleus legumen Gm.

[x] Not found at Inhaca.

Rock	Sand
Mollusca (65)	
	ˣTapes sulcaria L.
	ˣTellina scobinata L.
Cerithium morus Lam.	Cypraea annulus L.
C. kochi Phil.	C. tigris L.
Cellana capensis Gm.	Harpa conoidales Lam.
ˣColumbella fulgurans Lam.	Melongena paradisaica (Martini)
C. mercatoria Lam.	Murex brevispina Lam.
Conus ebraeus L.	Nassa arcularia L.
C. vermiculatus Lam.	N. coronata Bruge
Cypraea onyx L.	ˣN. margaritifera ?
C. vitellus L.	Natica didyma Bolten
C. helvola L.	N. mariochinensis Lam.
ˣDolabella sp. M. 52/55	Polynices mamilla L.
Drupa tuberculata (Blainville)	Strombus gibberulus L.
Littorina obesa Sowerby	Trochus nigropunctatus Rve.
L. scabra L.	
Mitra sp.	
Monilea obscura Wood.	
Nerita albicilla L.	
N. plicata L.	
N. polita Lam.	
N. textilis Gm.	
ˣN. undata (Less.)	
Peristernia leucothea Melville	
Planaxis sulcata Born	
Pusiostoma mendicaria Lam.	
Siphonaria carbo Hanley	
S. oculus Krauss	
Terebra affinis Gray	
ˣSistrum horridum (Quay)	
Thais intermedia Kiener	
T. mancinella (L.)	
Tectarius natalensis (Philippi)	

ˣ Not found at Inhaca.

Rock	Sand

Mollusca (65)

Thecaria sp. M. 60/55
[x]Trochus mauritianus Gm.
Turbo marmoratus L.
Urosalpinx heptagonalis Rve.
[x]Vasum turbinellum L.
Vermetus sp. In. 61/54
[x]Vertagus obeliscus
[x]Cavolina sp. M. 61/55

Crustacea (63)

Actaea rüppellii (Krauss)
Aniculus strigatus (Herbst)
Charybdis merguiensis de Man
[x]Chlorodopsis areolata (M. Edw.)
[x]Cryptodromia tomentosa (Heller)
Dehaanius 4-dentatus (Krauss)
Elamena mathaei (Desm.)
Epixanthus frontalis (M. Edw.)
Eriphia scabricula Dana
E. smithi McLeay
Etisus laevimanus Randall
Eucrate sulcatifrons Stimpson
Eurüppellia annulipes M. Edw.
Grapsus maculatus (Gatesby)
G. strigosus (Herbst)
[x]Hypocolpus diverticulatus (Strahl)
Libya plumosa Barnard
Menaethius monoceros (Latreille)
Metopograpsus messor (Forskall)
[x]Metopograpsus oceanicus
[x]Micippe philyra (Herbst)
Percnon planissimum (Herbst)
Petrolisthes lamarcki (Leach)
Pilumnus trichorophoides de Man

Calappa hepatica (L.)
[x]Calcinus gaimardi (M. Edw.)
C. laevimanus (Randall)
Clibanarius longitarsus (de Haan)
C. padavensis de Man
C. virescens (Krauss)
Coenobita rugosus M. Edw.
Cyphocarcinus capreolus (Paulson)
Diogenes senex Heller
D. avarus Heller
Emerita austroafricana Schmitt.
Eumedomus granulosus MacGilch
[x]Hippa adactyla Fabr.
Hymenosoma orbiculare Desm.
Lissocarcinus orbicularis Dana
Macropthalmus bosci Audouin
Ocypode ceratophthalmus (Pallas)
O. kuhli de Haan
Philyra platychira de Haan

[x] Not found at Inhaca.

Rock	Sand
Crustacea (63)	
P. vespitilio Fabr.	
[x]Pseudomicippe nodosa	
Thalamita crenata (Latreille)	
[x]T. picta Stimpson	
Trapezia cymodoce (Herbst)	
T. guttata Rüppell	
Xantho exaratus (M. Edw.)	
[x]Zosimus aeneus (L.)	
Alpheus edwardsi Audouin	Lysiosqilla maculata (Fabr.)
A. gracilis	Penaeid juveniles
[x]Calinnidea typa Stebbing	Pseudosquilla ciliata (Fabr.)
Sphaeroma serratum Fabricius	Processa aequimana (Paulson)
Chthamalus dentatus Krauss	
Balanus amphitrite va. communis Darwin	
[x]Pyrgoma milleporae (On Millepora coral)	
[x]Tetraclita sp. M. 72/55	
Echinodermata (48)	
Asterina burtoni Gray	
Culcita schmideliana (Retzius)	
Linckia multifora (Lam.)	
[x]Nardoa variolata (Retzius)	
Protoreaster linckii (Blain)	Pentaceraster mammillatus (Audouin)
[x]Retaster cribrosus (von Matens)	
Ophiactis savignyi (M. & Trosch.)	
O. modesta Brock	Amphioplus integer (Ljungman)
Ophiocoma scolopendrina (Lam.)	
O. valenciae (Muller & Trosch.)	
[x]Ophioderma sp.	
Ophiomastix venosa Peters	Ophiothela beauforti (Engel)
Diadema setosa (Leske)	
Echinometra mathaei Blain.	Eucidaris metularia (Lam.)

[x] Not found at Inhaca.

Rock	Sand
Echinodermata (48)	
ˣHeterocentrotus mammillatus (L.)	
ˣPrionocidaris pistillata (Lam.)	Salmacis bicolor Agassiz
Tripneutes gratilla (Lam.)	Temnopleurus toreumaticus (Lask.)
Actinopygia mauritiana (Q. & G.)	Holothuria difficilis Semper
A. plegeja (Selenka)	ˣH. erinaceus Semper
Holothuria atra Jager	H. impatiens Gm.
H. cinerascens Lampert	H. leucospilota Lampert
H. cumulus Clark	H. hilla Lesson
Stichopus chloronatus Brandt	H. parva Lampert
	H. pervicax Selenka
	H. scabra Jaeger (Santa Carolina)
	Opheodesoma mauritiae Heding
Crinoid sp. M. 56/55	Synapta oceanica (Lesson.)
Ascidiacea (9)	*Enteropneusta* (3)
ˣAplidium altarium (Sluiter)	Balanoglossus studiosorum van der Horst.
ˣA. petrense Michaelson	Ptychodera flava Eschscholtz
ˣDidemnopsis sansibaricum Michaelson	Willeyia delagoae van der Horst.
ˣDidemnun psammatodes (Sluiter)	
Eudistoma rhodopyge (Sluiter)	
E. mobiusi (Hartmeyer)	Branchiostoma sp.
E. passlerioides Michaelson	
ˣHerdmania morus (Sav.)	
ˣPolyclinum macrophyllum Michaelson	
Pisces (18)	
Abudefdef sordidus (Forskal)	
Amphiprion polymnus (Linn.)	
ˣAriosoma anago (Schlegel)	

ˣ Not found at Inhaca.

Rock

Pisces (18)

Antennablennius bifilium (Gunther)
Bathygobius fuscus Rüppel
Echidna nebulosa (Ahl.)
Epinephelus merra (Bloch)
[x]Enneapterygius obtusirostre Wunzinger
[x]Gobius albomaculatus Rüppel
G. capistratus Peters
G. nebulosus (Forskal)
Halmablemnnius dussumieri (Cuv)
Omobranchus striatus (Jatzow & Lenz)
Pardachirus marmoratus (Lacepede)
Pomacentrus annulatus Peters
Saurida gracilis (Q. & G.)
Siderea picta (Ahl.)
Stethojulis sp.

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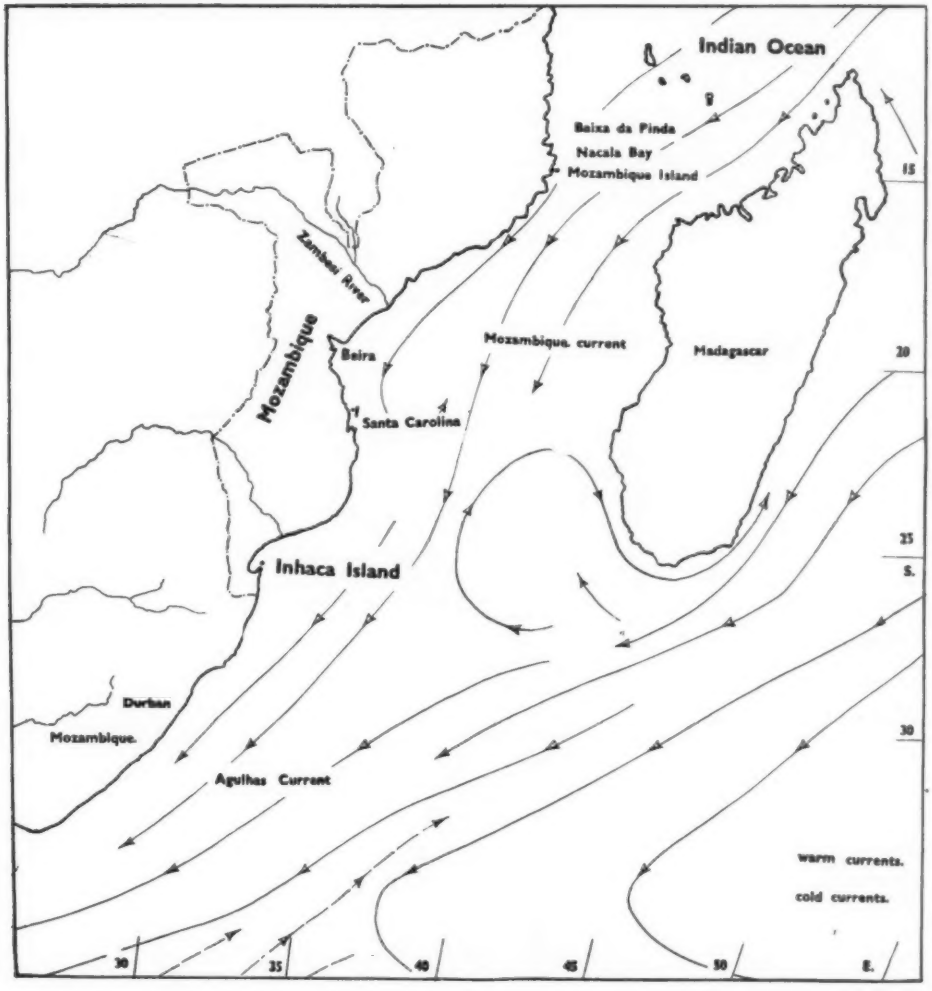


Fig. 1 — Map of Southern Africa showing the ocean currents and the shores examined.

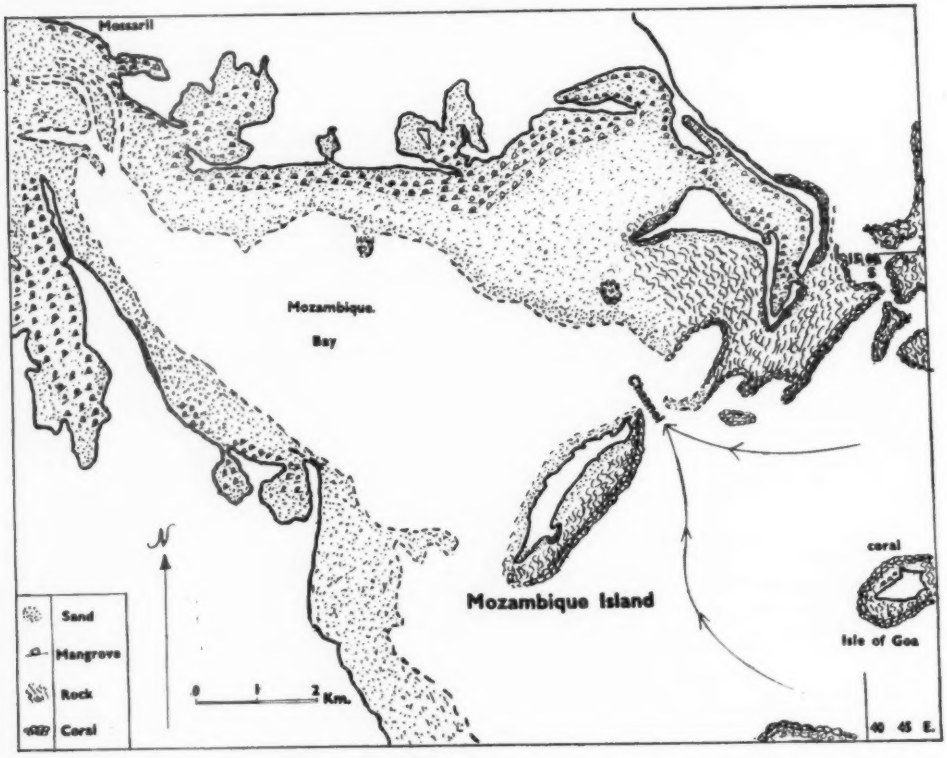


Fig. 2 — Map of Moçambique Bay showing the shores, the islands and the coral reefs.

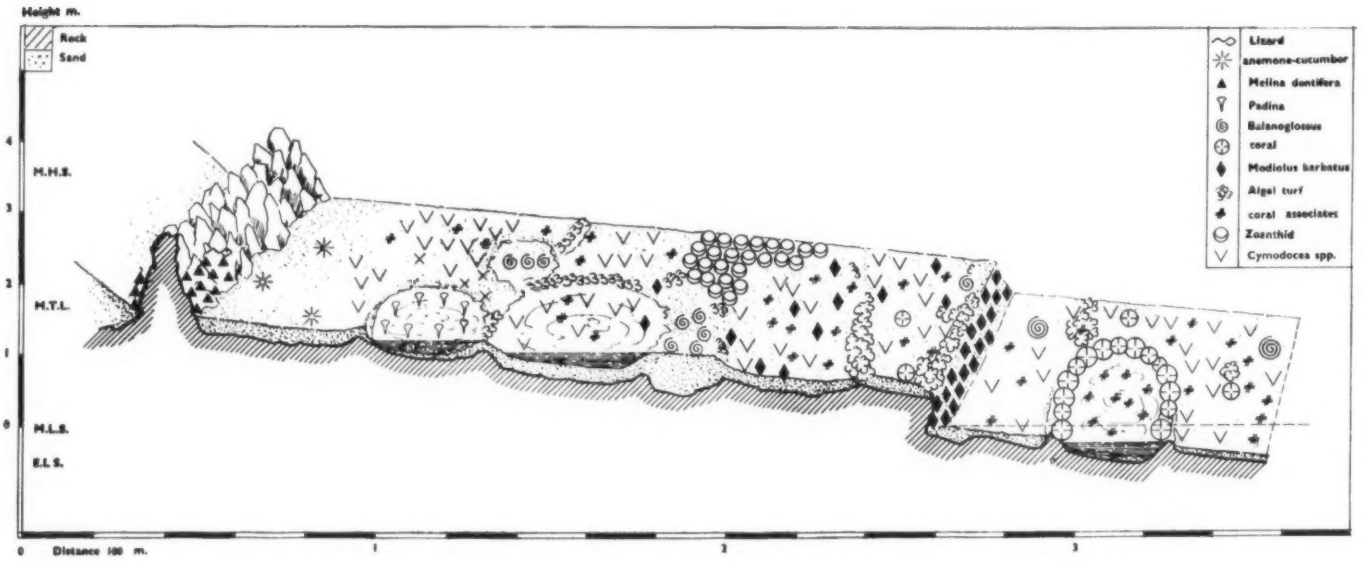
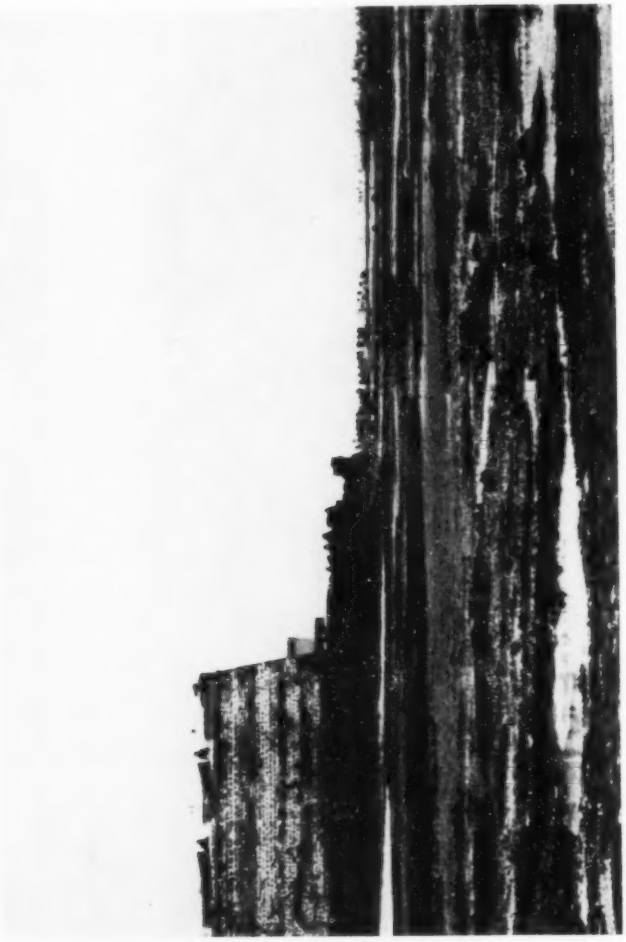


Fig. 3 — The pattern of distribution of common animals on the north-east rocks, Moçambique Island.



The semi-exposed shore at the north-east point of Moçambique Island.

A CARYOLOGICAL CONTRIBUTION TOWARDS THE TAXONOMY OF THE *COARCTATAE* SECTION OF *HAWORTHIA*

by

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INTRODUCTION

The *Coarctatae* have been, one of the most studied sections of the genus *Haworthia* (*Aloinae* sub-tribe) both in the fields of pure systematics, and caryosystematics and caryogenetics.

From the point of view of pure systematics, BERGER (1908) in his monograph distinguishes 8 species, and von POELLNITZ (1936) and RESENDE (1941) found and described new species and varieties. RESENDE (1943) and RESENDE & PINTO-LOPES (1946) in their systematical reviews of all known forms, named 20 species, 15 varieties and 4 forms. SMITH (1943, 1944, 1945, 1948) and BROWN (1946, 1950, 1951, 1952, 1953, 1954, 1956, 1957) added descriptions of new *taxa* bringing up to 47 the present number of *taxa* of the section (see Table).

RESENDE & PINTO-LOPES in their above mentioned papers called attention to the extraordinary phenotypic lability exhibited by this section (and also by the whole *Aloinae* sub-tribe) and the consequent difficulty of its systematics.

Caryosystematical and caryogenetical studies were first carried out by FERGUSON (1926) and continued later by RESENDE (1936, 1937, 1938, 1940, 1949), SATÔ (1937), MULLER (1945), PINTO-LOPES (1944, 1946), RESENDE & VIVEIROS (1948), PINTO-LOPES & RESENDE (1949), VIVEIROS (1951) and SNOAD (1955).

Among other findings, these studies showed the existence of many polyploid forms (eu-and aneuploids) and point to the probable hybrid nature of the many members of the section.

Thus, PINTO-LOPES (1944) found natural polyploid series, both inter- and

TABLE

Taxa of the Coarctatae Section known up to the present

Haw. armstrongii v. P.
» *carrissoi* RES.
» *cassytha* BAK.
» *coarctata* Haw. var. *coarctata* RES.

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* Bolseiro do Instituto de Alta Cultura.

Haw. coarctata Haw. var. *krausii* Res.
» *eilyae* v. P. var. *poellnitzeana* Res.
» » » » *zantnereana* Res.
» *fulva* G. G. Smith
» *glauca* Bak.
» *greenii* Bak. f. *greenii* Res.
» » » » *minor* Res.
» » » » *pseudocoarctata* (v. P.) Res. e P. L.
» » » » *silvicola* G. G. Smith
» *henriquesii* Res.
» *herrei* v. P. var. *poellnitzii* Res.
» » » » *depauperata* v. P.
» *jacobseniana* v. P.
» *ionesiae* v. P.
» *kewensis* v. P.
» *lisbonensis* Res.
» *musculina* G. G. Smith
» *peacockii* Bak.
» *resendeana* v. P.
» *reinwardtii* Haw. var. *adelaidensis* v. P.
» » » » *archibaldiae* v. P.
» » » » *bellula* G. G. Smith
» » » » *brevicula* G. G. Smith
» » » » *chalumnensis* G. G. Smith
» » » » *chalwinii* (M. e B.) Res.
» » » » *committeesensis* G. G. Smith
» » » » *conspicua* v. P.
» » » » *diminuta* G. G. Smith
» » » » *fallax* v. P.
» » » » *kaffirdriftensis* G. G. Smith
» » » » *major* Bak.
» » » » *minor* Bak.
» » » » *olivacea* G. G. Smith
» » » » *reinwardtii* Res.
» » » » *tenuis* G. G. Smith
» » » » *triebnerii* Res.
» » » » *valida* G. G. Smith
» » » » *zebrina* G. G. Smith
» *rewendetii* Uit.
» *rubrobrunea* v. P.
» *sampaiana* Res.
» » f. *broteriana* (Res.) Res. e P. L.
» *skinnerii* (Berger) Res.

intraspecific, and RESENDE & PINTO-LOPES (1946), after showing the great ease with which these plants hybridize, discuss the origin and taxonomy of some forms, and conclude to their hybrid origin.

RESENDE & VIVEIROS (1948) in continuation of these studies, obtained further evidence of the role of hybridization in the production of new forms.

All these data lead to the conclusion that the whole *Aloinae* sub-tribe, besides the *Coarctatae* section, is still an evolving group (RESENDE & VIVEIROS 1948, RESENDE 1949).

This group shows a marked variability which is both pheno- and genotypically determined. Ease of hybridization and frequency of polyploid formation complicate taxonomical studies specially when the taxonomist is outside the *areale* of these plants (RESENDE 1949, pag. 3).

In preparation for studies in experimental taxonomy RESENDE has been cultivating in the Lisbon Botanical Garden all the *taxa* of his collection of *Coarctatae*. The availability of a large number of plants obtained by sexual reproduction of some forms of this section, offered a good opportunity to carry out a caryological study in order to assess its taxonomic value within the section (cf. RESENDE & VIVEIROS 1948, pag. 188), and also to confirm the self-sterility of those species which show the greatest ease for interbreeding.

MATERIAL AND METHODS

The present study is concerned with 356 plants obtained by seeds sown in 1945 and which cover the following species, varieties and forms:

Haworthia sampaiana RES.
» *rewendetii* Uit.
» *reinwardtii* Haw. var. *reinwardtii* RES.
» » » » *minor* BAK.
» » » » *fallax* v. P.
» » » » *archibaldiae* v. P.
» *coarctata* Haw. var. *coarctata* RES.
» » » » *krausii* RES.
» *greenii* BAK. for. *greenii* RES.
» » » » *pseudocoarctata* (v. P.) RES. e P. L.
» *jacobseniana* v. P.
» *herrei* v. P. var. *depauperata* v. P.
» *armstrongii* v. P.
» *lisbonensis* RES.

All the mother plants were grown in pots in the open air and scattered throughout the Botanical Garden, all capsules with viable seeds being

formed spontaneously. The seeds showed normal germination and the F_1 plants obtained were maintained in the same environmental conditions.

Cytological observations were made on smears of root tip meristems stained by the Feulgen method. In most plants observations and counts were made on the large chromosomes since it is very difficult to carry this out with the small (1) chromosomes when their number is high.

FERTILITY AND STERILITY

In the vast literature on the *Aloinae* we find a number of studies on the subject of fertility and sterility.

Thus BERGER (1908) working on *Aloe* considers the species of this genus self-sterile although stamen and carpel conformation are clearly favourable to self-pollination.

MARSHAK (1934), in order to detect factors of self-sterility, carried out many self- and cross-pollination experiments with species of *Gasteria* and *Haworthia*. All species were shown to be self-sterile with the exception of 3 species of *Gasteria* which formed abnormal capsules with very few seeds. In cross-pollination tests, however, all the species of this genus were inter-fertile.

SEARS (1937) considered self-sterile the species of *Gasteria* and *Haworthia* he worked with, and attempted to explain this self-sterility. His observations, mainly in *Gasteria*, showed that growth of pollen tubes and fertilization were normal but that irregularity in tegument development resulted in ovule degenerescence.

RESENDE (1943) found that, in species of *Gasteria*, *Haworthia* and *Aloe*, the processes linked with fertility and sterility were, in general, largely dependent on environmental conditions. Though he did not attempt to analyse in detail this subject he is convinced that the majority of the *Aloinae* is self-sterile and that the influence of environmental conditions is exerted indirectly by affecting insect life (personal communication).

All these results indicate that self-fertility does not take place at least within the majority of the *Aloinae*. Our own relatively few observations on the *Coarctatae* lead to the same conclusion.

In the green houses of the Lisbon Botanical Garden a large number of species and varieties of this section is maintained, and although they flower profusely every year, not a single capsule has yet been observed to form. However, when brought out into the open air, where they flower equally well, large numbers of capsules are formed.

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(1) The haploid set of the *Aloinae* always show 4 large and 3 small chromosomes.

Since it is well known that in many *Aloinae* pollination is carried out by insects or other animals (cf. BERGER 1908) this behaviour under green house conditions must be largely due to absence of pollinating agents though some effect may also come from conditions of light intensity and thermoperiodism. Capsule formation in the open air must therefore, in most cases be the result of intra- or interspecific cross-pollinations.

SPECIES

Haw. sampaiana RES.(1) ($2n = 36$)(2)

RESENDE & PINTO-LOPES (1946) consider 2 forms: *Haw. sampaiana* RES. $2n = 36$ (21 large and 15 small chromosomes) and *Haw. sampaiana* for. *broteriana* (RES.) RES. e PINTO-LOPES, $2n = 35$, 2 pentaploid forms, the latter being hyperpentaploid.

In their paper *Haw. sampaiana* RES. is held as self-fertile, and in reference to its F_1 they write: «Therefore we are dealing with an aneuploid form which probably gives various forms of different numbers of chromosomes and amongst these forms there will be also some pentaploids certanly different amongst themselves. Among these pentaploids of the F_1 e F_2 etc. there may also appear *Haw. Rewendetii* Uit.».

The 43 F_1 plants studied had chromosome numbers (large chromosomes) varying between the aneuploid numbers $2n = 17$ and 23, the most frequent being $2n = 18$ (see graph 1). The low (4) frequency of occurence of the euploid number $2n = 20$ suggests that we may be dealing with a *taxon* with $2n = 16$ large chromosomes and 1 to 6 or more extra- or accessory ones.

Since $2n = 18$ approaches the mother plant chromosome number (21 large chromosomes), F_1 may have resulted from self-pollination or cross-pollination within the species.

Another possibility would be a cross between *Haw. sampaiana* and tetraploid forms of the *Coarctatae* section, gametes coming from the former and exhibiting, as a rule, 10 large chromosomes.

These plants are not uniform as to phenotype, considerable morphological differences being observed even between those with the same number of chromosomes. Figs. 1-4 show some differing most from the mother plant.

On the basis of shape and size of leaves, their arrangement on the axis and tubercule number and coalescence we may consider 2 groups: one, phenotypically within the *Coarctatae* (fig. 1); the other very like the *Limifolia*

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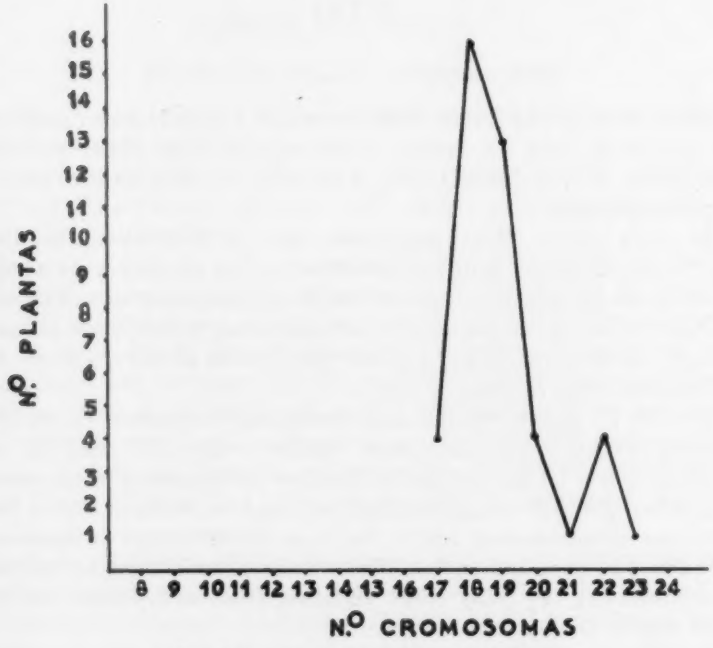
(1) RES. = RESENDE. Other abbreviations in this paper, v. P. = von POELLNITZ, BAK. = BAKER, HAW. = HAWORTHIA, UIT. = UITEWAAL, P. L. = PINTO-LOPES, M. e B. = MARLOTH and BERGER.

(2) In the text mother plant zygotic number follows the species name.

(fig. 2) but showing a distended stem as in *Coarctatae* and not the typical *Limifolia* rosette. This and the fact that the juvenile aspects of these (fig. 3) closely aproach *Haw. tesselata* (cf. RESENDE & PINTO-LOPES 1946, pag. 176) lead one to consider *Haw. sampaiana* a hybrid containing genes from 3 different sections: *Coarctatae, Limifolia* and *Tesselata* which exhibit during development, variations of dominance or epistasis (RESENDE & WARDEN 1954, BUSCH & RESENDE 1957, RESENDE 1957). Figs. 1-3 shows aspects of these 3 sections.



Graph 1 — F_1 of *Haw. sampaiana* RES.

A new phenotype for *Haworthia* was also observed (figs. 4, 4 *a*): leaf arrangement, instead of parastical, showed 5 orthostics whith *Haw. coarctata* leaves (cf. also RESENDE & VIVEIROS 1948, pag. 181 and RESENDE & VIVEIROS 1959).

Since none of the 43 plants resembled *Haw. sampaiana* for. *broteriana* and *Haw. rewendetii* (cf. RESENDE & PINTO-LOPES 1946, pag. 181) it seems reasonable to conclude that these pentaploids have had another origin. BROWN (1952) considered, as RESENDE did in 1943, *Haw. sampaiana* for. *broteriana* as a separate species from *Haw. sampaiana* in view of the extent to which they differ from each other. Our observations would have led us to the same conclusions had we not considered morphological characters of less value than physiological

Fig. 1

Fig. 2

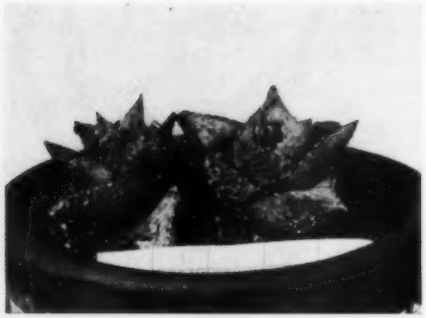


Fig. 3

Fig. 4

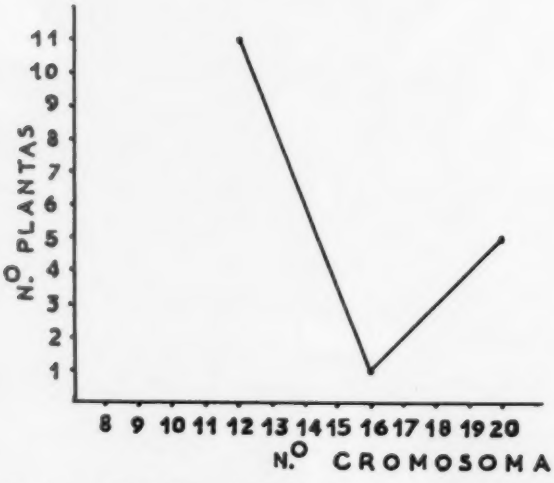
Fig. 4*a*

Fig. 5

ones (=structural) as did Resende & Pinto-Lopes. As to *Haw. rewendetii*, the observations on 4 F_1 specimens from 1 mother plant showed no change of phenotype from the mother plant (fig. 5), indicating that they originated from self-pollination or an intraspecific crossing which hypothesis is supported by the fact that their chromosome number is the same as of the mother plant — quite an unusual case for a pentaploid.

Haw. reinwardtii Haw. var. *reinwardtii* Res. ($2n = 28$)

Seventeen F_1 plants were studied and 2 groups could be established: one of 11 triploids intermediat phenotypically between this variety and the variety *minor* (fig. 6) the other 6 approaching closely the phenotype of *Haw.*



Graph 2 — F_1 of *Haw. reinwardtii* Haw. var. *reinwardtii* Res.

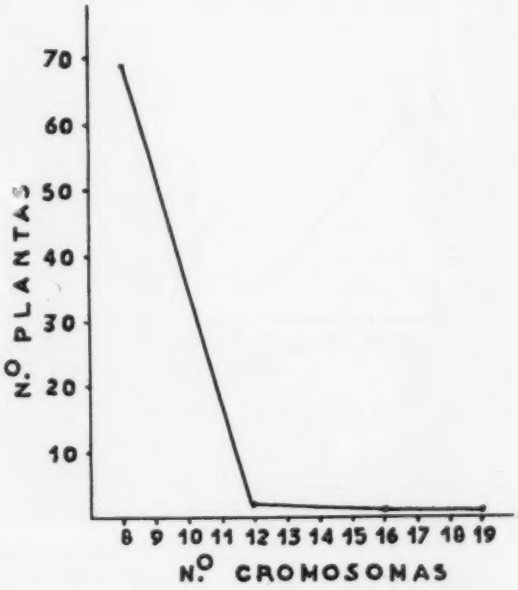
coarctata (fig. 7). It is almost certain that the first group originated from a cross between *Haw. reinwardtii* var. *reinwardtii* and a diploid strain of *Haw. reinwardtii* probably from the *minor* variety.

As to the remainig 6 plants, though phenotypically very uniform, it is difficult to decide on their origin in view of their different chromosome numbers: 16 and 20 large chromosomes (see graph 2).

However, it is not unlikely that the 5 plants showing 20 large chromosomes may have resulted from a cross between var. *reinwardtii* and a hexaploid strain of *Haw. coarctata*, probably the *krausii* variety.

Haw. reinwardtii Haw. var. *minor* Bak. ($2n = 14$)

The great majority (69) of the 73 F_1 plants showed the parent chromosome number (see graph 3) which indicates a self-pollination origin. Phenotype however, is not uniform and the plants may be grouped as follows:



Graph 3 — F_1 of *Haw. reinwardtii* Haw. var. *minor* Bak.

23 showing the characters of the mother plant (fig. 8), 10 with the *Haw. lisbonensis*(1) phenotype but showing a long stem (fig. 9), 1 plant very much like *Haw. reinwardtii* var. *archibaldiae* (fig. 10). The remaining plants show characters intermediate between *Haw. lisbonensis* (small leafed) and *Haw. reinwardtii* var. *minor* (apparent tubercules).

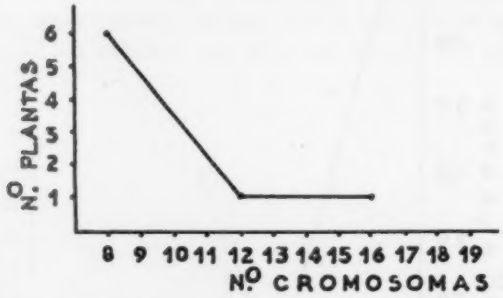
The second group (10 plants) may have come from a cross between *Haw. reinwardtii* var. *minor* and *Haw. lisbonensis*. The plant shown in fig. 10 is perhaps a cross between Haw. *reinwardtii* var. *minor* and *archibaldiae* variety ($2n = 3x = 21$) gametes which would exhibit $n = 7$ chromosomes.

(1) Smith considers this species as belonging to the *Rigidae* section and not to the *Coarctatae*.

Haw reinwardtii Haw. var. *fallax* v. P. ($2n = 28$)

Eight F_1 plants were studied and 2 groups could be separated: one with 5 plants phenotypically similar to *Haw. lisbonensis* but with longer stems (fig. 11) and another of plants approaching *Haw. reinwardtii.*

It is of interest to point out that 4 of the 5 plants of the first group are diploids, the other being a tetraploid (see graph 4); this plant does not resemble the mother plant at all although it shows the same chromosome number.



Graph 4 — F_1 of *Haw. reinwardtii* Haw. var. *fallax* v. P.

From the second group, 2 plants were diploids and the third a triploid. Here we have either a mistake in the label of the seeds or a regularization of the chromosome number.

Haw. reinwardtii Haw. var. *archibaldiae* v. P. ($2n = 21$)

Though we did not possess descendents of this variety it was thought of interest to compare it with a specimen sent us by Dodson (U. S. A.) and classified by G. G. Smith as a new variety: *Haw. reinwardtii* var. *chalumnensis* G. G. Smith (Jour. South Africa Bot. IX). Its close morfological similarity to var. *archibaldiae* does not, in our opinion, justify its setting apart as a new variety, moreover, its description as a new variety (l. c. pag. 99) fits into the general outlines for var. *archibaldiae.* It is also a triploid.

The heterosis exhibited by var. *archibaldiae* may be due to its hybrid nature which is admitted by Resende & Pinto Lopes (1946, pag. 188).

Haw. coarctata Haw. ($2n = 42$)

Resende (1943) distinguishes two varieties: var. *coarctata* and var. *kraussi;* he even considered a further splitting of the former into the forms *major* and *pseudocoarctata.* Resende & Pinto-Lopes (1946) nullified this, identifying the form *pseudocoarctata* with a form of *Haw. greenii.*

Fig. 6

Fig. 7

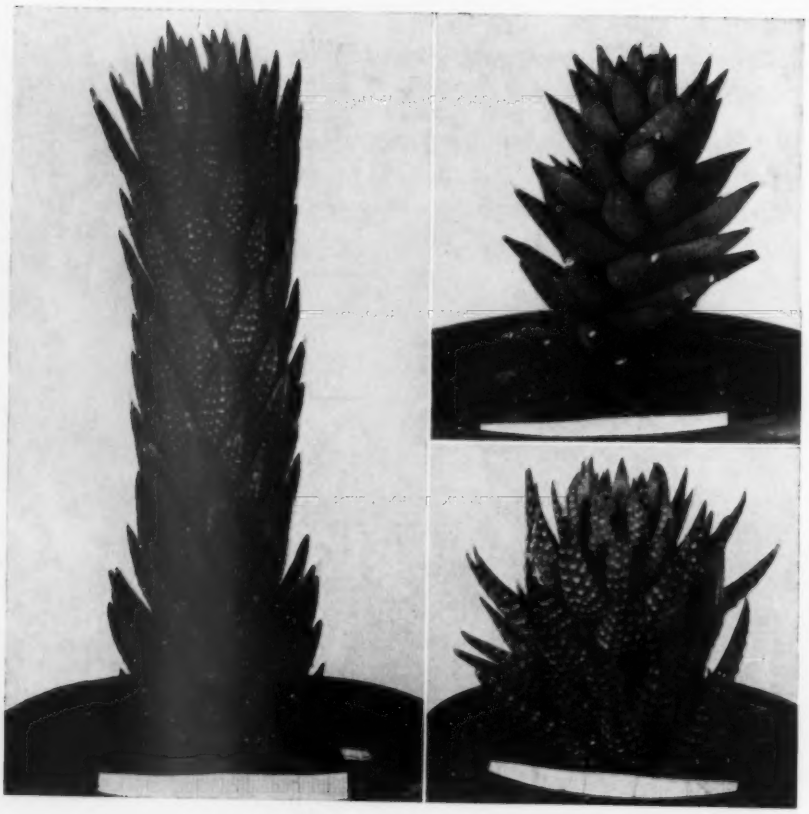
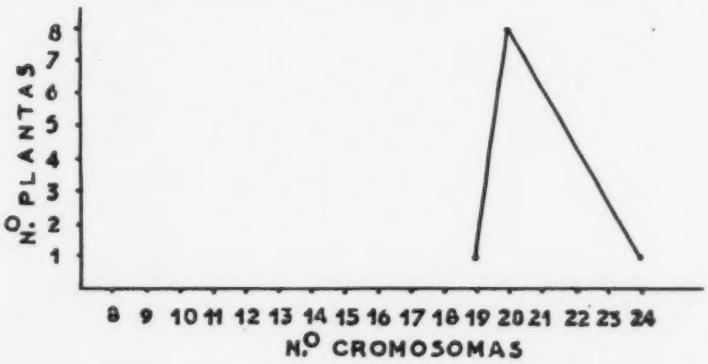


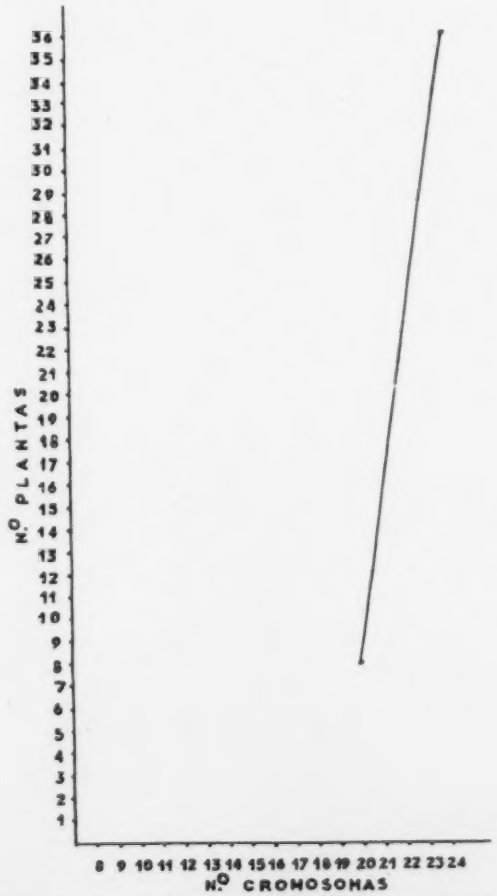
Fig. 8

Fig. 9

Fig. 10



Graph 5 — F_1 of *Haw. coarctata* Haw. var. *coarctata* Res.



Graph 6 — F_1 of *Haw. coarctata* Haw. var. *krausii* Res.

I. var. *coarctata* Res.

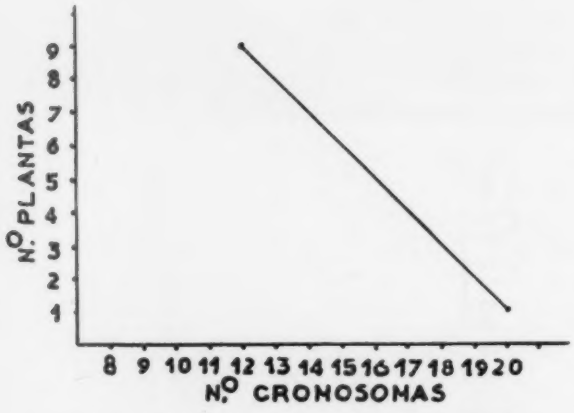
Of the 10 F_1 plants studied, 6 of them (all showing 20 large chromosomes) showed a phenotype resembling *Haw. sampaiana* or *Haw. tesselata* (fig. 12, 12 *a*); the 4 others, though showing also the same phenotype, possessed different chromosome numbers (see graph 5) and may be placed between *Haw. coarctata* var. *coarctata* and *Haw. reinwardtii.*

II. var. *krausii* Res.

The 44 F_1 plant studied were relatively uniform in phenotype, most of them like the typical *Haw. coarctata* with a great frequency of the *krausii* aspects. Some were *krausii* without tubercules. Three plants (fig. 13) remind one of a short leafed *Haw. sampaiana.* The same mother plant chromosome number (24 large chromosomes) was observed in 36 of the 44 F_1 plants (see graph 6), indicating their origin as result of self-pollination or of intraspecific cross.

Haw. greenii Bak. for. *greenii* Res. ($2n = 28$)

Of the 10 F_1 plants, 7 were like the mother plant (fig. 14) and 3 like *Haw. reinwardtii* (figs. 15, 15 *a*).



Graph 7 — F_1 of *Haw. greenii* Bak. for. *greenii* Res.

Since the mother plant is tetraploid ($2n = 28$) the fact that 9 out of the 10 plants are triploids (see graph 7) points to their hybrid origin, probably from a cross with a diploid form of *Haw. reinwardtii.*

Fig. 11

Fig. 13

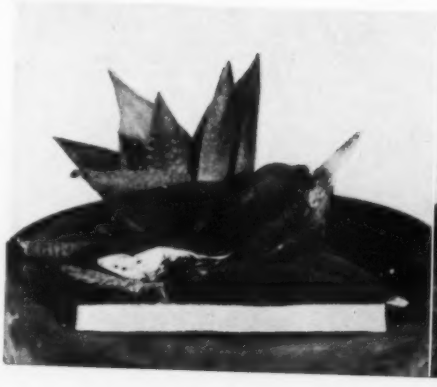


Fig. 12

Fig. 12*a*

Pig. 14

Fig. 15

Fig. 15*a*

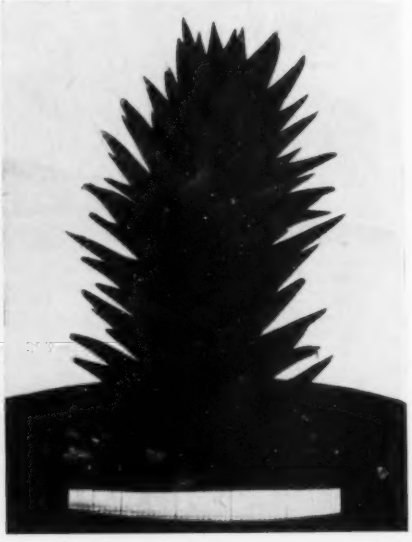
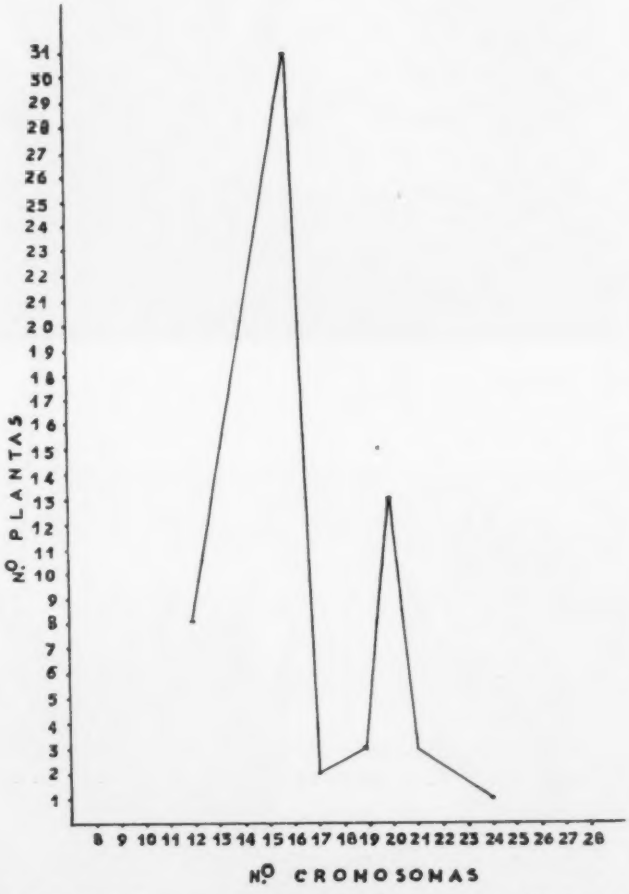


Fig. 16

Haw. greenii Bak. for. *pseudocoarctata* (v. P.) Res. et P. L. ($2n = 28$)

The 61 F_1 plants show a considerable uniformity in phenotype but intermediate between *Haw. greenii, Haw. coarctata* and *Haw. reinwardtii* (cf. Resende 1949, pag. 11).



Graph 8 — F_1 of *Haw. greenii* Bak. for. *pseudocoarctata* (v. P.) Res. et P. L.

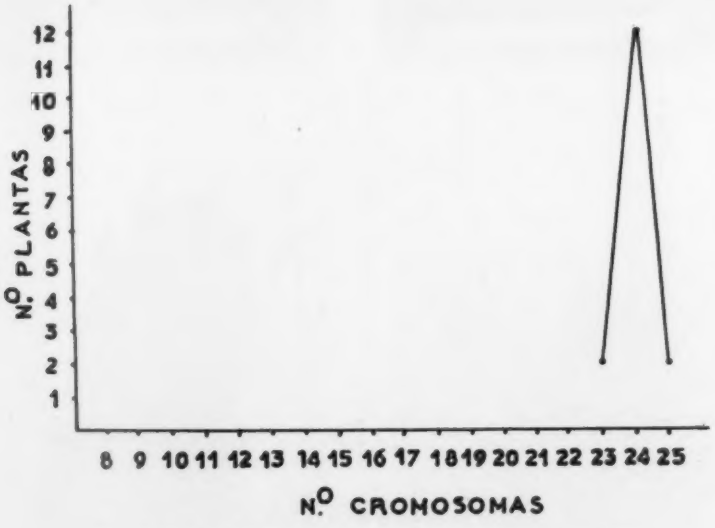
The high incidence (31 plants) of the mother plant chromosome number (16 large chromosomes) point to self-pollination or to intraspecific crossing in these plants but not in the other 30 plants for they show a great diversity in chromosome numbers (see graph 8).

Haw. jacobseniana v. P. ($2n = 14$)

Two groups could be distinguished: one resembling the mother plant, the other *Haw. lisbonensis* (fig. 16). Being all diploids, it is reasonable to admit self-pollination or intraspecific crossing in the first group and a cross with *Haw. lisbonensis* in the second.

Haw. herrei v. P. var. *depauperata* v. P. ($2n = 42$)

All F_1 plants show a phenotype intermediate between *Haw. herrei* var. *herrei* ($2n = 14$), *Haw. ionesiae* ($2n = 14$) and *Haw. jacobseniana* ($2n = 14$) (fig. 17) with the exception of one which is like *Haw. reinwardtii* (fig. 18). The majority have the mother plant chromosome number (24 large chromosomes) (see graph 9).



Graph 9 — F_1 of *Haw. herrei* v. P. var. *depauperata* v. P.

Haw. armstrongii v. P. ($2n = 42$)

Out of 26 F_1 plants 3 are fundamentally like the mother plant (fig. 19). The others may be divided into 2 groups one intermediate between the

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 21

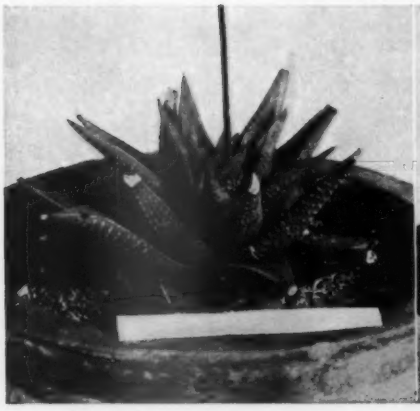


Fig. 22

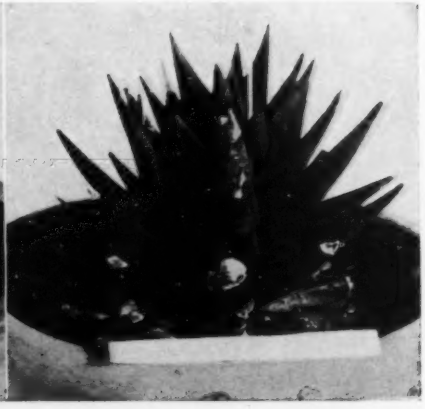
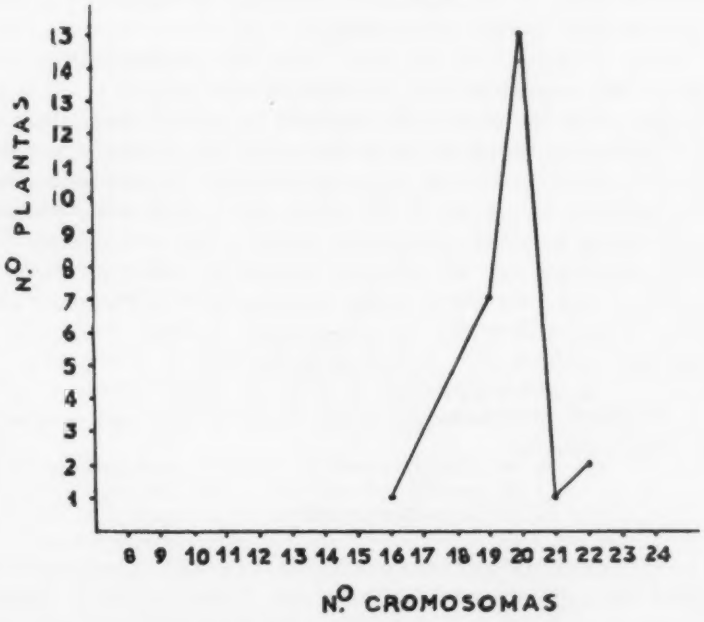


Fig. 23

mother plant and *Haw. reinwardtii* (fig. 20); the other, between the mother plant, *Haw. jacobseniana* and *Haw. ionesiae.*

Their numbers of large chromosomes range from 16 to 22 (see graph 10).



Graph 10 — F_1 of *Haw. armstrongii* v. P.

Haw. lisbonensis Res. ($2n = 14$)

All 31 F_1 are diploid and 29 are phenotypically like the mother (fig. 21) and must therefore have derived either from self-pollination or intraspecific cross. The other 2 plants differing from the mother plant (figs. 22 and 23) may have derived from cross-pollination.

Resende (1949 pag. 8) made allowance for the hybrid origin of this species but this hypothesis may be questioned in the light of its phenotypically uniform F_1.

CONCLUSIONS

The study of the F_1 of the different *taxa* of the *Coarctatae* section revealed a marked incidence of considerably different morphological types in the majority of the *taxa* collected as experimental material. The differences observed within some F_1 may go as far as to cover characters of 3 different sections (see the case of *Haw. sampaiana*).

Though these plants are very liable to phenotypically determined variability (cf. RESENDE 1949, pag. 65) this may be ignored as all these plants have been grown in identical environmental conditions since 1945. The morphological differences observed must therefore be genetically conditioned.

On the other hand, the caryological study showed great diversity of chromosome numbers in almost all F_1 plants and in most cases no correlations could be established between chromosome number and morphology (about the origin of F_1 plants see pag. 27) different phenotypes showing the same chromosome number; different chromosome numbers within the same phenotype.

This frequent diversity of chromosome number leads one to admit that the majority of these F_1 plants was originated by interspecific crossing. This conclusion is not surprising as BERGER (1908), RESENDE (1943) and RESENDE & VIVEIROS (1948) have called attention to the great ease with which these plants form hybrids.

SUMMARY

1 — Within many species and side by side with phenotypic lability of morphological characters a very considerable lability is also registered for genetical quantity (polyploidy). These characters are, however, not correlated, external aspects giving no indication of quantitative differences linked to polyploid structures.

2 — It seems that no degree of polyploidy ($2-6x$) is a barrier to intercrossing.

3 — Above degree 2 of polyploidy, various aneuploid numbers are possible and tolerance for higher numbers of acessory chromosomes (all of them euchromatic) increases as the degree of n rises (cf. *Haw. sampaiana* graph, and VIVEIROS, 1949 in *Haw. tesselata* var. *luisieri* with 7 super numerary chromosomes, see also RESENDE & VIVEIROS, 1959).

Even at degree $2n$ a species carrying spontaneous chromosomic mutation (*Haw. browniana*) was observed to be viable (RESENDE & DA FRANCA 1946).

4 — So great is the ease for hybridizing between the most extreme degrees of polyploidy and between species belonging to different sections that we considered necessary a revision of the set of morphological characters which has formed, up to the present, the basis of systematics. A new type of grouping of plants into species and of species into sections is called for in

view of the extraordinary biological similarity so frequently observed between sections and between species.

The morphological differences given systematical value up to the present, although genetically determined and with broad phenotipically determined variability curves, do not correspond to great structural differences (cytogenical and physiological). The species of the genus *Haworthia* are an outstanding example of antithesis together with certain species of the genus *Drosophila* (cf. DOBZHANSKY 1951, pag. 273).

5 — In certain cases caryology allowed us to detect similarities between *taxa* and to recognize different names as synonimous (e. g. *Haw. reinwardtii* var. *chalumnensis* G. G. SMITH). Also it made possible the detection of a hybrid when an odd number of n was determined (e. g. *Haw. sampaiana*, *Haw. reinwardtii* etc.). The study of F_1 from *Haw. sampaiana* showed its hybrid origin whilst that of *Haw. rewendetii* did not. In this species the only 3 F_1 plants studied were both phenotypically and chromosomically uniform which fact points to zygotic apomyxy as to origin of F_1.

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CONCERNING THE GENESIS OF THE CHROMOPLASTS OF SOME FRUITS

by

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The present confused and controversial state of this subject (cf. f. i. WEIER, 1942; STRAUS, 1950, 1953, 1954; ZURZYKI, 1954; ROBERTS, 1942; ROBERTS and SOUTHWIK, 1948; COUTINHO et al, 1956) is in the writers' opinion due to the lack of an unequivocal definition of chromoplast.

There are at least two different kinds of red to yellow pigmented cell formations, indisputably related to the chloroplast: *a*) the stigma of the Flagellates, Protococcales, gametes and zoospores of the Ulotricales and the flagellated gametes of the Phaeophyceae (cf. f. i. DE REZENDE-PINTO, 1958) to wich are imputed phototatic functions; *b*) those resulting from the degeneration of certain chloroplasts, specially, but not exclusively of some fruits whose intrinsic functional activity does not seem to be as clear as the one shown by the *stigmata*.

Besides those mentioned there can also be found certain coloured formations that some authors consider as being chromoplasts (cf. f. i. STRAUS loc. cit.), while others consider them as mere crystals (cf. f. i. WEIER, loc. cit.).

This discussion will continue endlessly unless we agree, as stated before to a clear-cut definition of chromoplast.

The present paper is limited to those formations undoubtedly related to the chloroplasts and which are found in the most varied fruits.

Our study was carried in the following species: *Ilex Aquifolium* L., *Pyracantha coccinea* Roem., *Rosa canina* L., *Rosa sps.*, *Withania somnifera* (L.) Dun., *Capsicum annuum* L., *C. «piri-piri»*, *Solanum ochroleucum* Bast., *S. miniatum* Ait., *S. heterodoxum* Dun., *S. macrophyllum* Hort., *S. pseudocapsicum* L., *S. capsicastrum* Link, *S. Lycopersicum* L., *Physalis pubescens* L., *Ph. Francheti* Mast., *Tamus communis* L., *Bryonia dioica* Jack., *Diospyros Kaki* L., *D. Lotus* L., *Passiflora coerulea* L., *Rauwolfia chinensis* Hemsl., *Melia Azederach* L., *Palisota Barteri* Hook. f., *Aspargus officinalis* L.

* * *

Technics used were:

a) For fruits with a soft pericarp, compression of very small fragments between slide and coverslip using the juice as mounting medium.

b) For immature fruits or those with a harder pericarp, or less juicy, microtome cuttings were used, which were mounted in 6-8 % sucrose water (cf. f. i. STRAUS 1953) or in liquid paraffin.

c) For ripe fruits, but with a soft pericarp we also used the freezing microtome. We never noticed here that the drop in temperature induced any clear structural alteration in the chromoplasts. This technics in fruit, where

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* Bolseiros do I. A. C., Lisboa.

there are many kinds of plasts, (f. i. *Aspargus officinalis*) presents an evident advantage, as it allows their localization.

* * *

In some species we took care to check on a phenomenon that the senior author had already observed: very frequently in completely developed but immature or nearly ripe fruits a deficient translocation takes place which sometimes gives rise to an excessive starch accumulation in the amylogenic vacuoles of some or even all chloroplasts — formation of chloroamyloplasts (DE REZENDE-PINTO, 1948) (Figs. 3, 8, 13, 19)*. From the transformation of this starch at the ripening of the fruits, result the carotinoids, that which can be seen either as drops or crystals inside the chromoplasts, or which after extrustion and crystallization in the fundamental cytoplasm, would form chromocrystallites.

Un to the present with the species studied by us, we have found six different types of chromoplasts (fig. 1) which we shall designate by the capital letters A to C, followed by the name of a species chosen as the type.

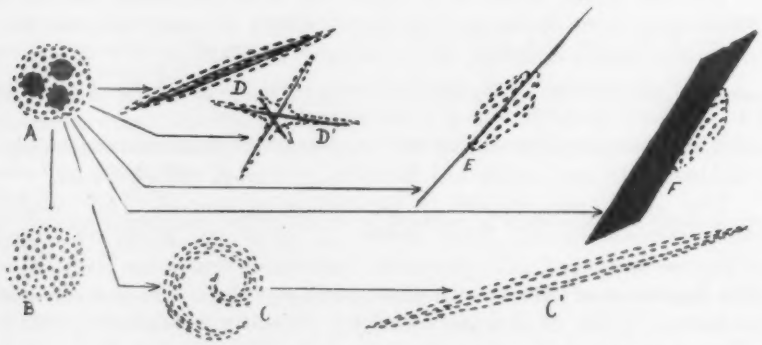

Fig. 1 — The relationship of various types of chromoplasts.

A. *Solanum ochroleucum* Bast. (figs. 2-6).

At the beginning the fruits show chloroplasts with the grana easyly seen, but as they approach the maturation phase, assimilated starch accumulates in the amylogen vacuoles of the chloroplasts, due possibly to a deficiency of translocation (1) (fig. 3).

The moment maturation begin, chloroamyloplast starch goes through a series of transformations with the production of more or less voluminous drops of chromolipids which remain inside the vacuoles of the stroma — chromoplasts — (figs. 1 A, 4, 5, 6).

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* The figures 2-27 are in the plates V-XVI.

(1) This translocation deficiency was observed to take place in an experimentally decortication (annular) branch of *Hedera helix* (DE REZENDE-PINTO, 1948) hence the explanation offered.

Solanum marginatum, S. miniatum, Melia Azederach, Rauwolfia chinensis, Ilex Aquifolium, behave in a similar way.

B. *Bryonia dioica* Jacq. (figs. 7-11).

During the development of the fruit we can see typical chloroplasts and, in a more advanced stage exceedingly abundant chloroamyloplasts with very large starch grains (fig. 8). The chromolipids derived from them are formed amidst the stroma (fig. 9), but afterwards diffuse outwards settling down in the grana which from then on appear deep red (figs. 1 B, 10).

It is not infrequent to find, in this species, some incompletely transformed starch grains to which we may attribute the anisotropy seen in some of these chromoplasts (fig. 11).

Solanum laciniatum, Citrus aurantium, C. medica, C. nobilis, show similar behaviour.

C. *Solanum pseudocapsicum* L. (figs. 12-17).

In the species of this type after the plasts have gone through all the phases of type B — chloroplasts (fig. 12), chloroamyloplasts (fig. 13), chromoplasts, (fig. 14) — the chromoplastonematic spirals become unwound (figs. 1 C, 1 C', 15), chromoplasts taking the shape of a very elongated spindle with a clearly observed anisotropy (fig. 17)(1).

Solanum capsicastrum, Pyracantha coccinea, Rosa canina, R. sps. Diospyrus Kaki, D. lotus, Palisota Barteri, Aspargus officinalis, were found to belong to the *Solanum pseudocapsicum* type.

D and E. *Physalis pubescens* L. (figs. 18-23).

These two last types D and E (fig. 1) are described together because they may be found in the same fruit and even in the same cell.

The chloroplasts (fig. 18) frequently change into chloroamyplasts (fig. 19) which in their turn, through the starch → chromolipid chain of reactions originate an intermediate state similar to the A type (figs. 1, 4, 5, 6).

As soon as the chromolipids are synthetised they form neadle-like cristals within the stroma vacuoles giving the plast a spindle-like shape (figs. 1 D, 20, 21), when the needle-like crystals grow parallel, when growth is in various directions, the plast is star-shaped (fig. 1 D').

The chromoplasts of: *Solanum Lycopersicum*(2), *S. heterodoxum, Capsicum annuum, C. «piri-piri»,* show this type of behaviour.

In other cases — E type — (figs. 1, 22, 23) possibly due to excessive crystal growth — beyond the limit of elasticity of the stroma and the plasto-

(1) Here his further evidence for the existence of plastonematic structure (DE REZENDE-PINTO, 1948) and we should like our opponents to explain the above phenomenon.

(2) In the main cytoplasm of *S. Lycopersicum* and *T. communis* we have constantly found certain coloured crystalline formations whose relationship with the plasts we have not yet been able to trace. They may show various forms but are always highly anisotropic. We shall consider them provisionally as chromocrystallites.

nematical involucre — the plast becomes crossed by crystalline needles. Also here the plastonematical structure is particularly evident and is in accordance with the alterations suffered by the chromoplasts.

In *Physalis pubescens* the grana of the chloroplast plastonemata may remain green — chloroplastonemata — or become more or less discoloured. The pigments, which crystallize inside the stroma vacuoles, do not normally diffuse towards the perifery of the plasts, as happens with the chromoplasts of the B and C types.

Solanum Lycopersicum, Tamus comunis, Passiflora coerulea, behave as above.

F. *Solanum macrophyllum* Hort. (figs. 24-27).

The photomicrographs show that genesis here is very similar to that of type E. The chromoplasts, however show, growing out of each of them, a very large parallelogram-like tobular chrystal (figs. 26, 27), whose larger surface exhibits a slight cork-screw twist.

Up to the present this is the only species showing type F chromoplasts.

CONCLUSIONS

From the above observations we may draw the following conclusions:

1. — The colours of the various fruits we had the opportunity to observe are not always due to plasts;

2. — Black or dark coloured fruits have chloroplasts and do not show chromoplasts.

3. — The various types of chromoplasts show interrelations (see fig. 1).

4. — In all the observed cases, the intermediate states of chromoplast genesis are irreversible.

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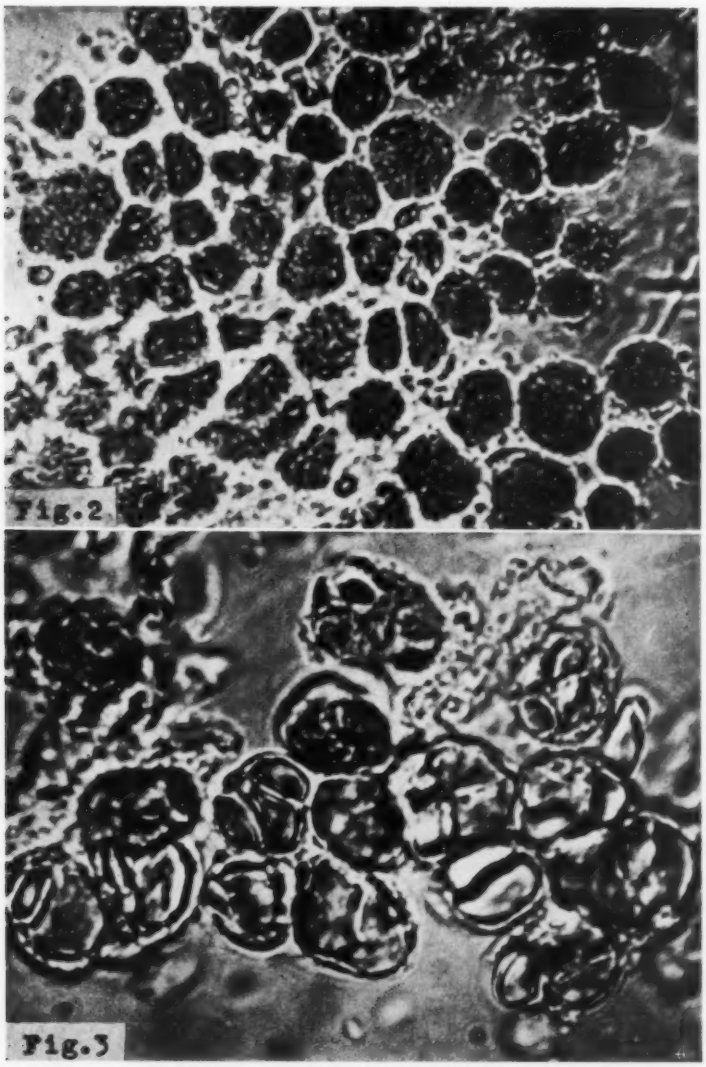
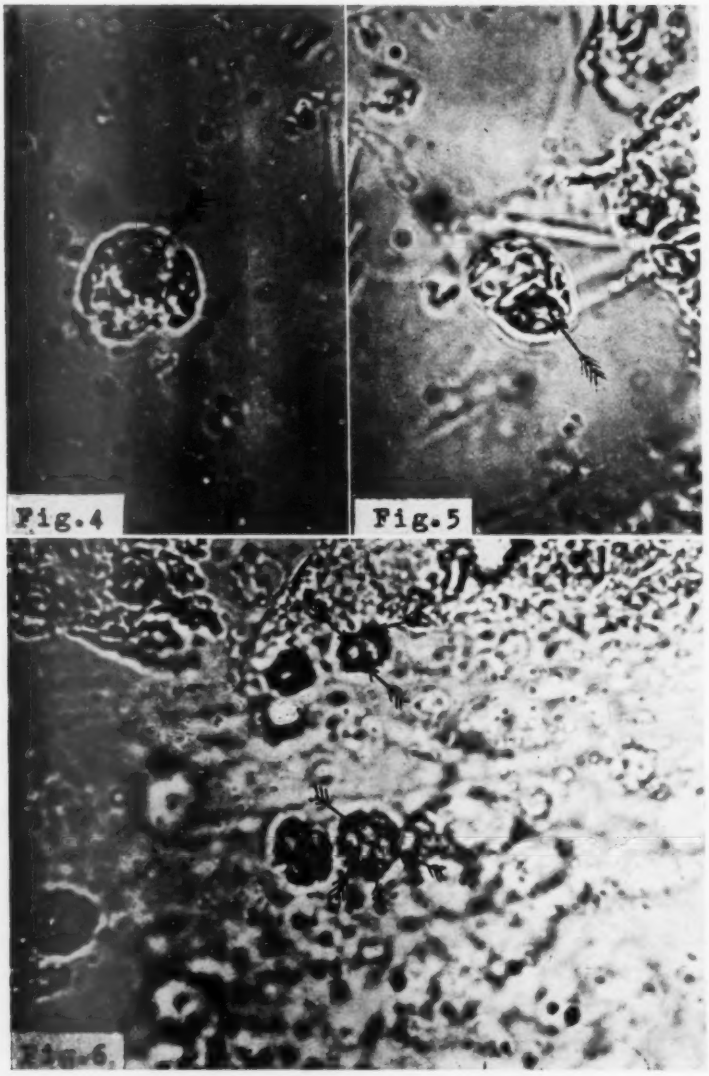


Solanum ochroleucum BAST.

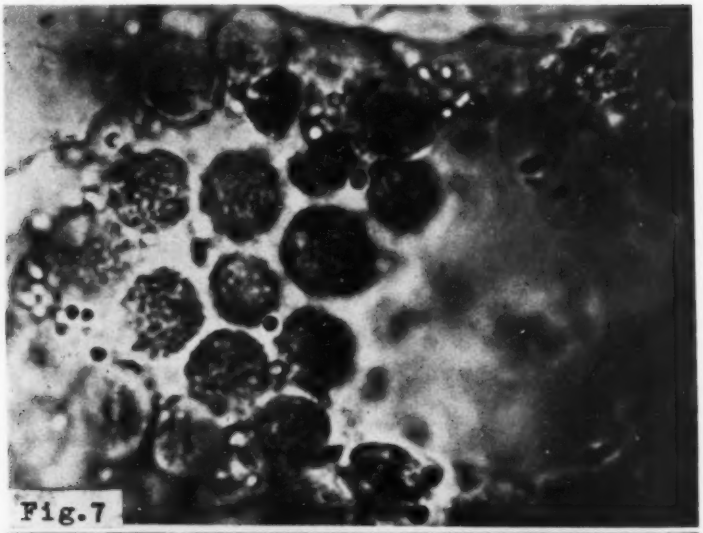
Fig. 2 — Chloroplasts, Fig. 3 – Chloroamyloplasts.

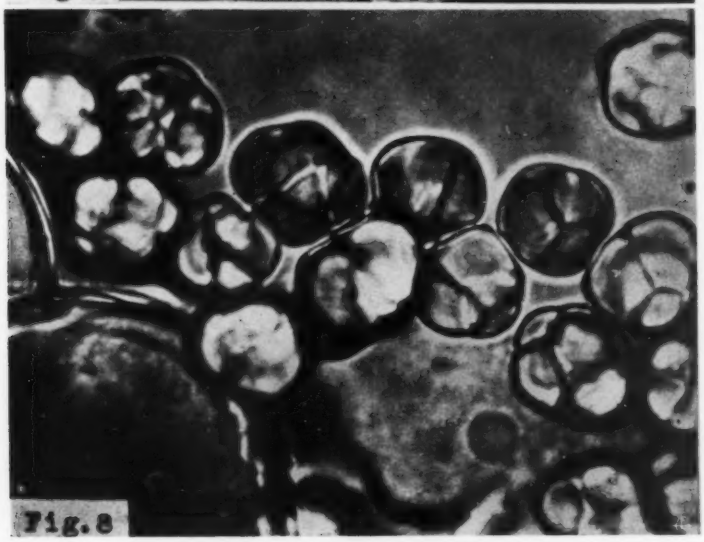


Solanum ochroleucum BAST.

Figs. 4, 5 and 6 — Chromoplasts — The arrows show the vacuoles of the stroma containing the chromolipids, in the liquid state, under the form of large drops one in each chromoplast.

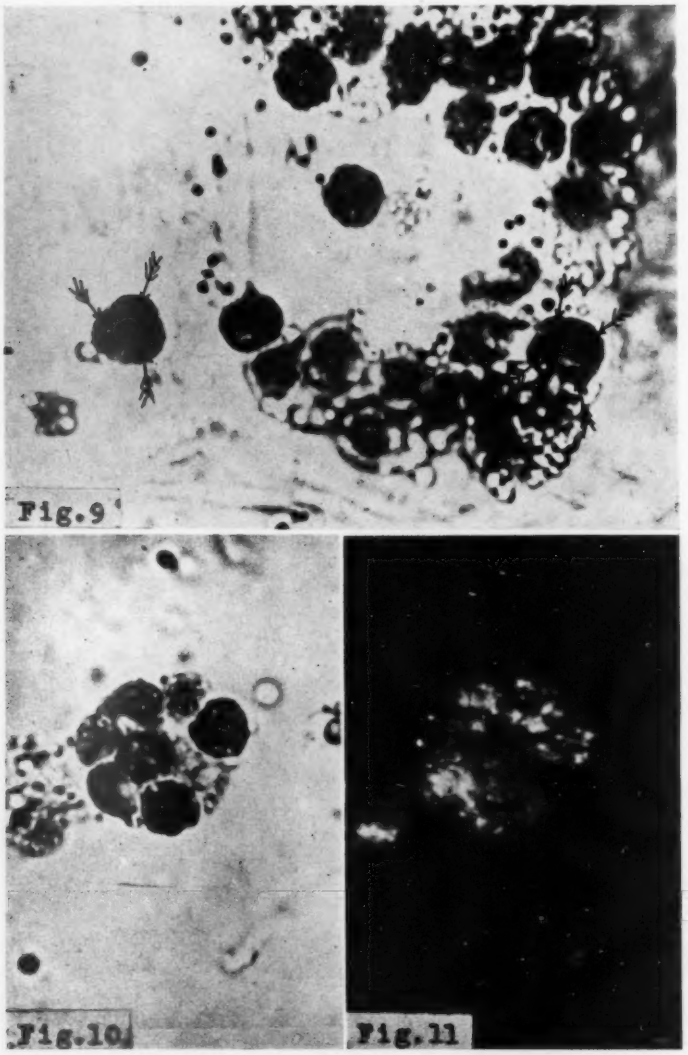
Fig. 6 — Chromoplasts possibly in a more advanced state of evolution which, in this species, represents the final stsge. The arrows show the various chromolipid droplets trapped in the stroma.





Bryonia dioica JACQ.

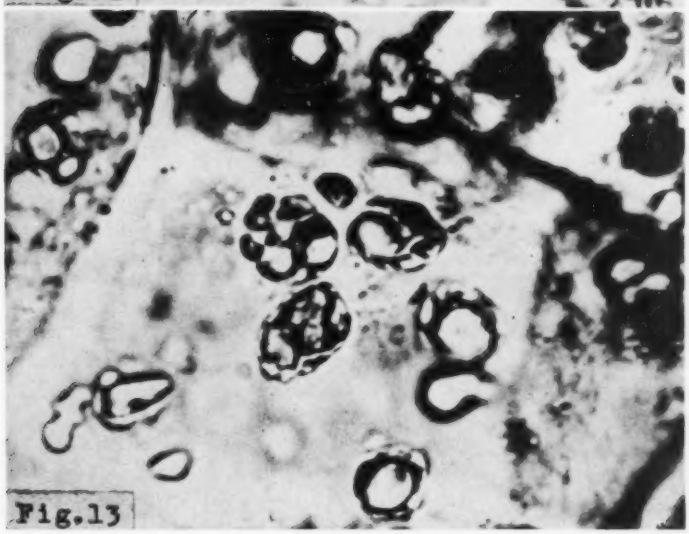
Fig. 7 – Chloroplasts, Fig. 8 — Chloroamyloplasts.



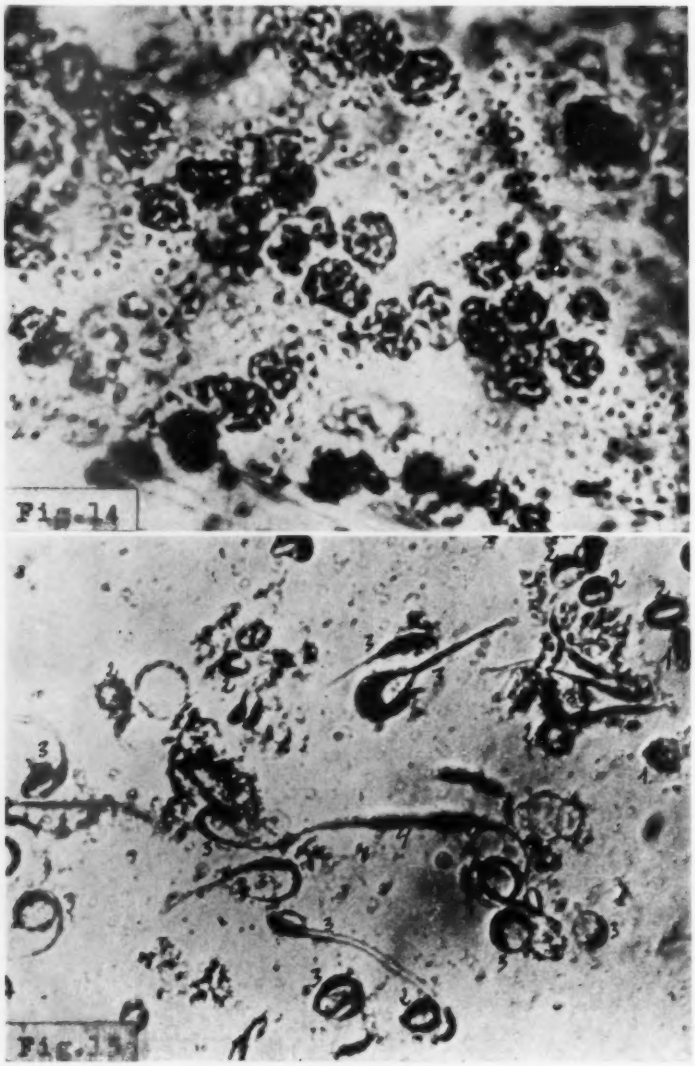
Bryonia dioica JACQ.

Eig. 9 — Chromoplasts, initial state. Inside the stroma of some of these chromoplasts (marked by arrows) we can clearly see vacuoles containing chromolipids, which in a more advanced state will diffuse outwards to the grana.

Figs. 10 and 11 — Chromoplasts seen respectively in natural and polarized light, between crossed nicols. Some chromoplasts show a very marked anisotropy which may be due to an incomplete chromolipoidization of the starch.



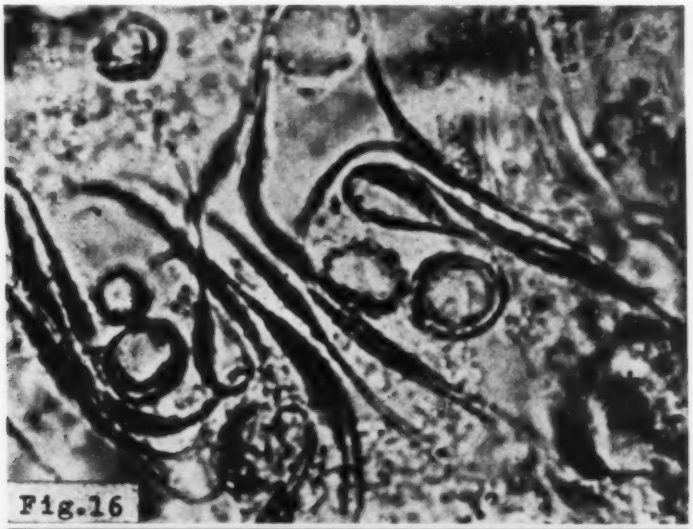
Solanum pseudocapsicum L.
Fig. 12 — Chloroplasts. Fig. 13 — Chloroamyloplasts.

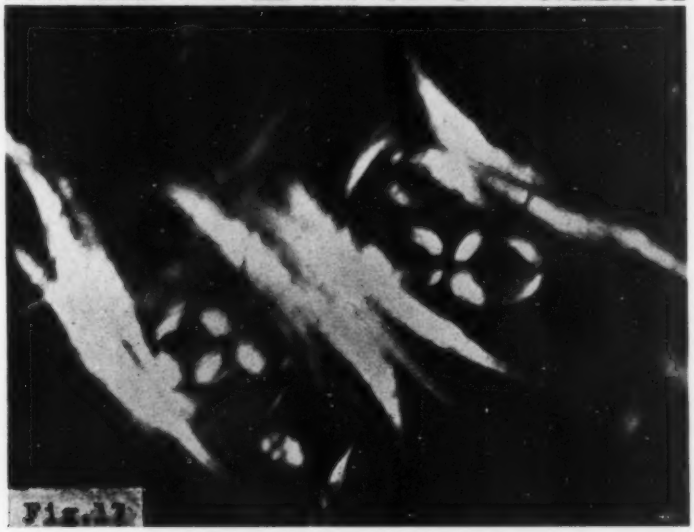


Solanum pseudocapsicum L.

Fig. 14 — Cromoplasts. Proceeding from the vacoules of the stroma the chromolipids establish themselves in the grana.

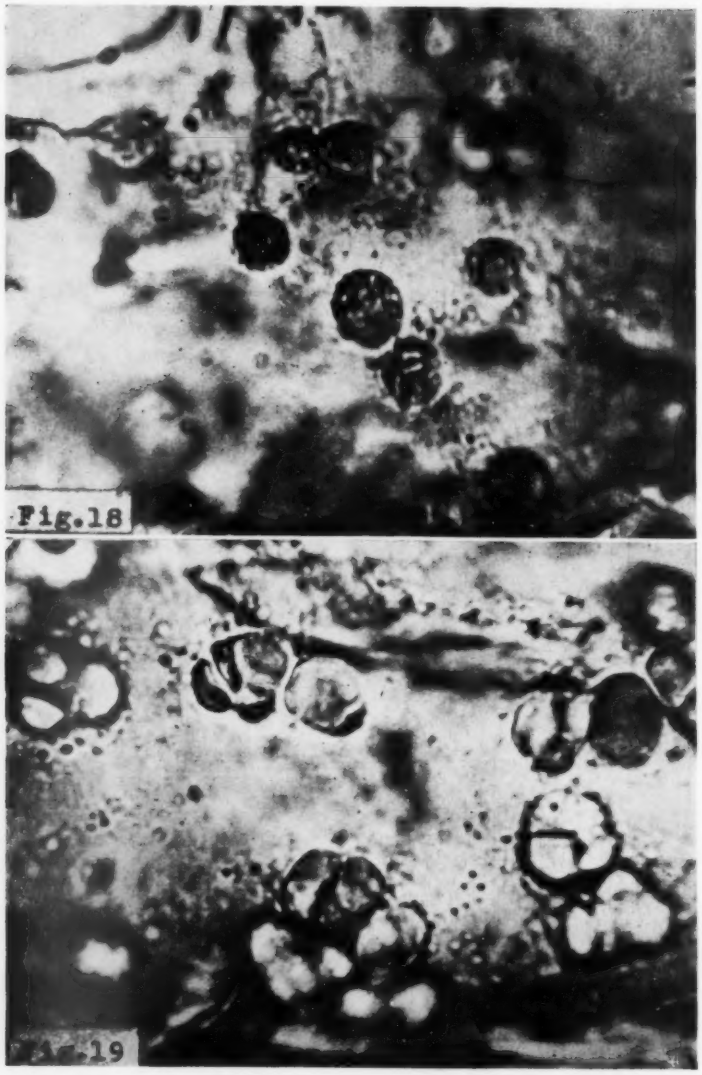
Fig. 15 — Chromoplasts. The numbers 1, 2, 3, 4, show the successive states of unwinding of the chromoplastonemata





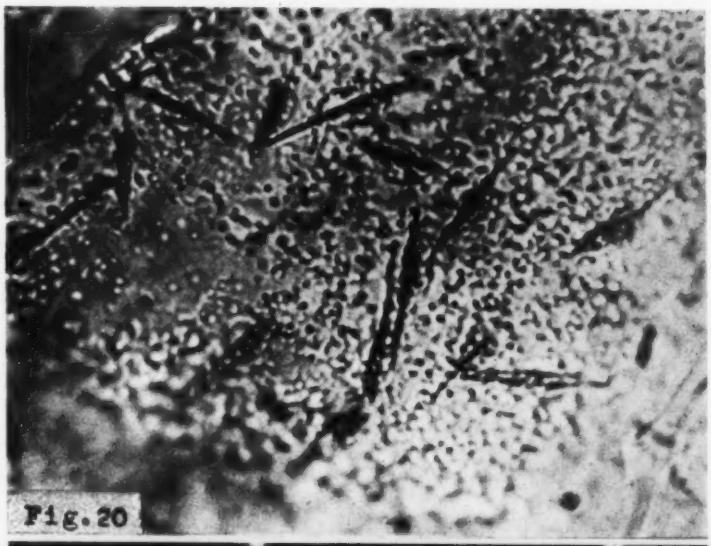
Solanum pseudocapsicum L.

Figs. 16 and 17 — Chromoplasts in different phases of unwinding seen in natural and polarized light between crossed nicols. Not the marked anisotropy of the chromoplastonemata in the wound state as well as afterwards when completelh unwound, n_γ // to chromoplastonemata.



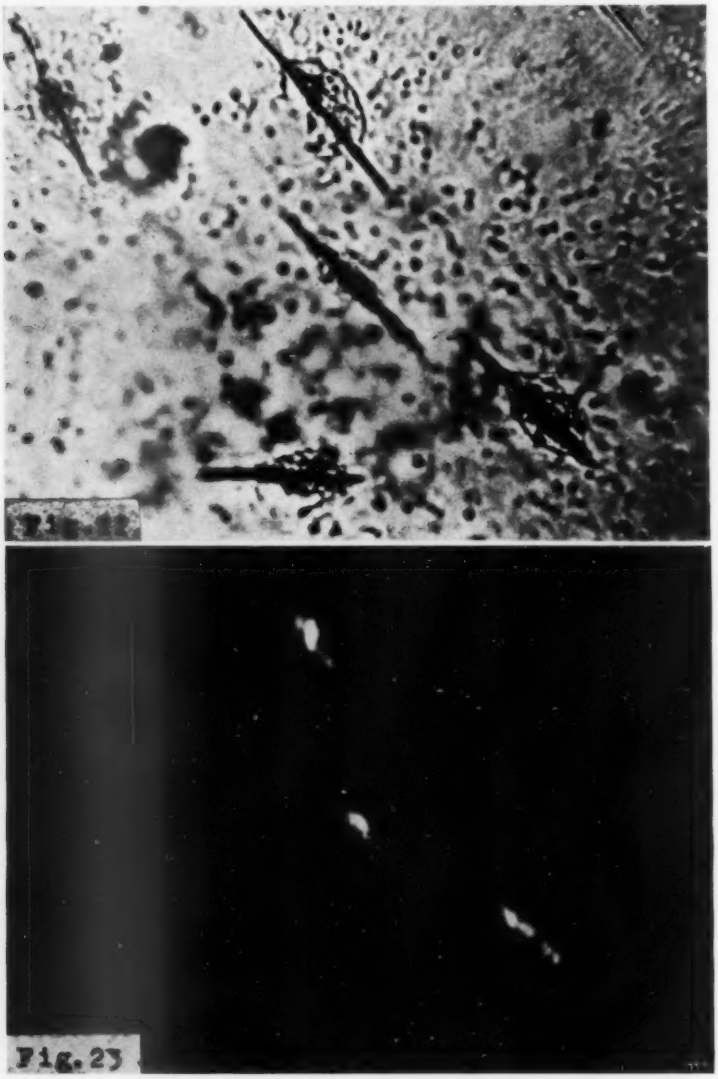
Physalis pubescens L.

Fig. 18 — Chloroplasts. Fig. 19 — Chloroamhloplasts.



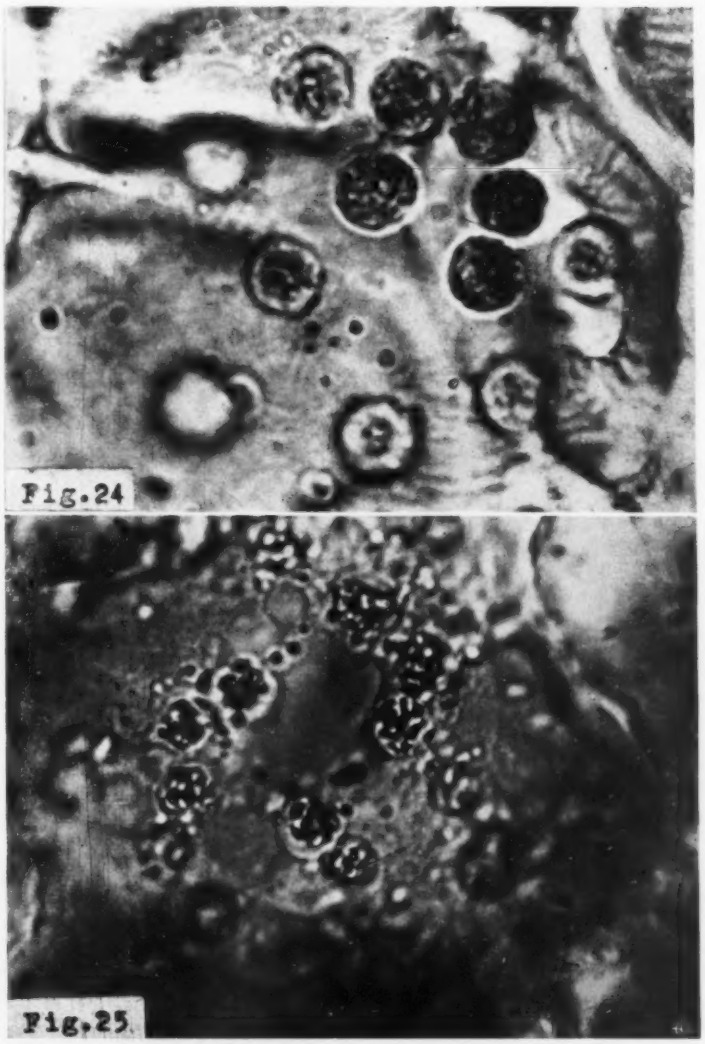
Physalis pubescens L.

Figs. 20 and 21 — Spindle-shaped chromoplasts seen in naturl and in polarized light, between crossed nicols. The elongated aspect of the chromoplasts is due to chromolipid crhstalization within the stroma.



Physalis pubescens L.

Figs. 22 and 23 – Chromoplasts seen in natural and polarized light, between crossed nicols. Owing to an excessive development of the chromocrystallites these pierce and grow out of the stroma and plastonemata which then revert to their previous shape.



Solanum macrophyllum HORT.

Fig. 24 – Chloroplasts. Fig. 25 - Chromoplasts at the beginning of development. The chromolipids are found in the stroma as droplets.

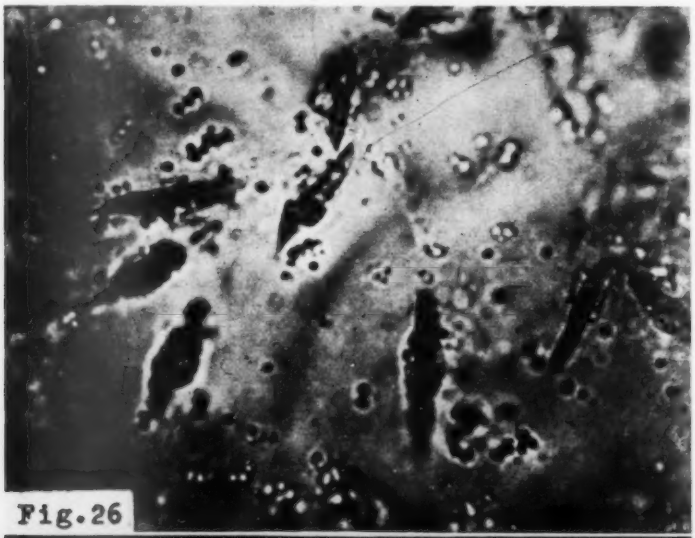


Fig.26

Fig.27

Solanum macrophyllum HORT.

Figs. 26 and 27 – Chromoplasts, similar (as to genesis) to those of *Physalis pubescens* (figs. 22 and 23), but with long tabular (instead of needle-shaped) crhstals showing a cork-screw twist.

A MIXOPLOIDIA SOMÁTICA E A ORIGEM DE NOVAS FORMAS GENETICAMENTE DIFERENTES NUM CLONE DE ×*BRYOKALANCHOË LISBONENSIS*

(«MUTAÇÃO» CLONAL)

por

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Instituto Botânico da Universidade de Lisboa: Depart. de Fisiologia e Genética

(Recebido em Julho 1, 1959)

WINKLER, no seu trabalho de 1916, sobre a obtenção de poliploides por enxerto, afirma ter observado células tetraploides nos tecidos de plantas diploides. Por causa da *existência normal dessas células nos tecidos*, não conclui WINKLER, nesse trabalho, que os brotos tetraploides, que obteve, se tivessem originado por fusão de células do caio, i. é., por zigotos somáticos.

Apesar disso, a convicção de que os seres pluricelulares tinham um número somático de cromosomas, n (gerações com núcleos gamofásicos), ou $2n$ (gerações com núcleos zigofásicos), constante e típico de cada forma, perdurou até há poucos anos. Neste último quarto de século verificou-se, porém, que o número de cromosomas, não só de tecido para tecido mas também dentro do mesmo tecido, pode mostrar grande variação nas plantas superiores. GEITLER e a sua escola têm sido os autores que mais têm contribuido para este reconhecimento (cf. GEITLER 1948, TSCHERMACK-VOSS 1959, RESENDE 1956a).

Nos animais superiores, inclusivé no homem, verifica-se a mesma variação do número somático de cromosomas (cf. SIMONEN & THERMAN 1956, MARQUARDT 1959).

Atendendo-se a esta variação de célula para célula, dentro do mesmo indivíduo, é preciso — ao considerar-se uma série poliploide intraspecifica ou intragenérica (interspecífica) — ter apenas em conta o número cromosómico do zigoto (gerações em $2n$) ou do esporo (gerações em n) de cada membro da série, pois o membro da série de grau poliploide mais baixo pode apresentar, nos seus diferentes tecidos meristemáticos e definitivos, números de cromosomas mais elevados que o número cromosómico do zigoto do representante mais elevado da série (fig. 1).

É interessante que o plasma germinal, i. é., os tecidos que vão dar os esporos, os ♂♂ e os ♀♀(1) (reprodução sexuada), e os que vão dar bolbilhos, pseudo-bolbilhos, nucelar-embrionia, etc. (reprodução assexuada) não mostrem normalmente(2) a «anarquia de números cromosómicos» que *normalmente* podem mostrar todos os tecidos vivos de qualquer órgão (fig. 1, l. g.). Em consequência disso, mantém-se *constante o número de cromosomas do zigoto, ou*

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(1) Quanto ao sexo dos esporos cf. RESENDE 1956b.

(2) Em *Solennobia* (borboleta) há também na linha germinal, números diferentes de cromosomas (cf. SERRA 1949 pág. 803), originando-se por partenogénese séries poliploides.

da célula ou células que o substituem na reprodução assexuada, dos diferentes indivíduos dum determinado grau da mesma série poliploide. O mesmo já não é de esperar nos processos de desagregação vegetativa quando esta se não faça por rebentos (1) mas sim por folha, de cujo parênquima células com números de cromosomas diferentes do número zigótico poderão ser as que originam a nova planta (cf. SERRA, 1949, pág. 602, nota 1).

O mesmo pode suceder por enxertia quando morra a parte terminal do garfo e só fique vivo o calo da base. Deste calo do caule, como da folha, pode ser o número zigótico — ao formar-se o novo rebento — substituído por um grupo de células somáticas dos parênquimas do caule de grau poliploide mais alto ou mais baixo que o do zigoto. Se somàticamente houver também, normalmente (2) distribuídas nos tecidos, mutações estructurais (cromosómicas ou génicas) poderão dos calos da folha ou do caule resultar também «mutantes» qualitativamente diferentes da planta-mãe (cf. RESENDE 1950, pág. 127-128).

* * *

Nesta nota, com carácter apenas de nota preliminar, apontaremos o que observamos ao pretendermos fazer um clone de × *Bryokalanchoë lisbonensis* a partir de folhas. Sobre a origem deste hibrido cf. RESENDE 1956c, 1959.

As folhas das *Kalanchoideae* em geral regeneram (além de pseudo-bolbilhos — *Bryophyllum* —) plantulas a partir de calos originados na base da folha ou de qualquer parte do limbo, onde se faça uma fractura, uma «ferida» (fig. 2). No «clone», que por este processo pretendíamos obter, observamos que 31 % das plantulas eram «genèticamente diferentes» da forma de *Bryokalanchoë lisbonensis* que tinha fornecido as folhas («cabeça de clone» ou «mãe do clone»):

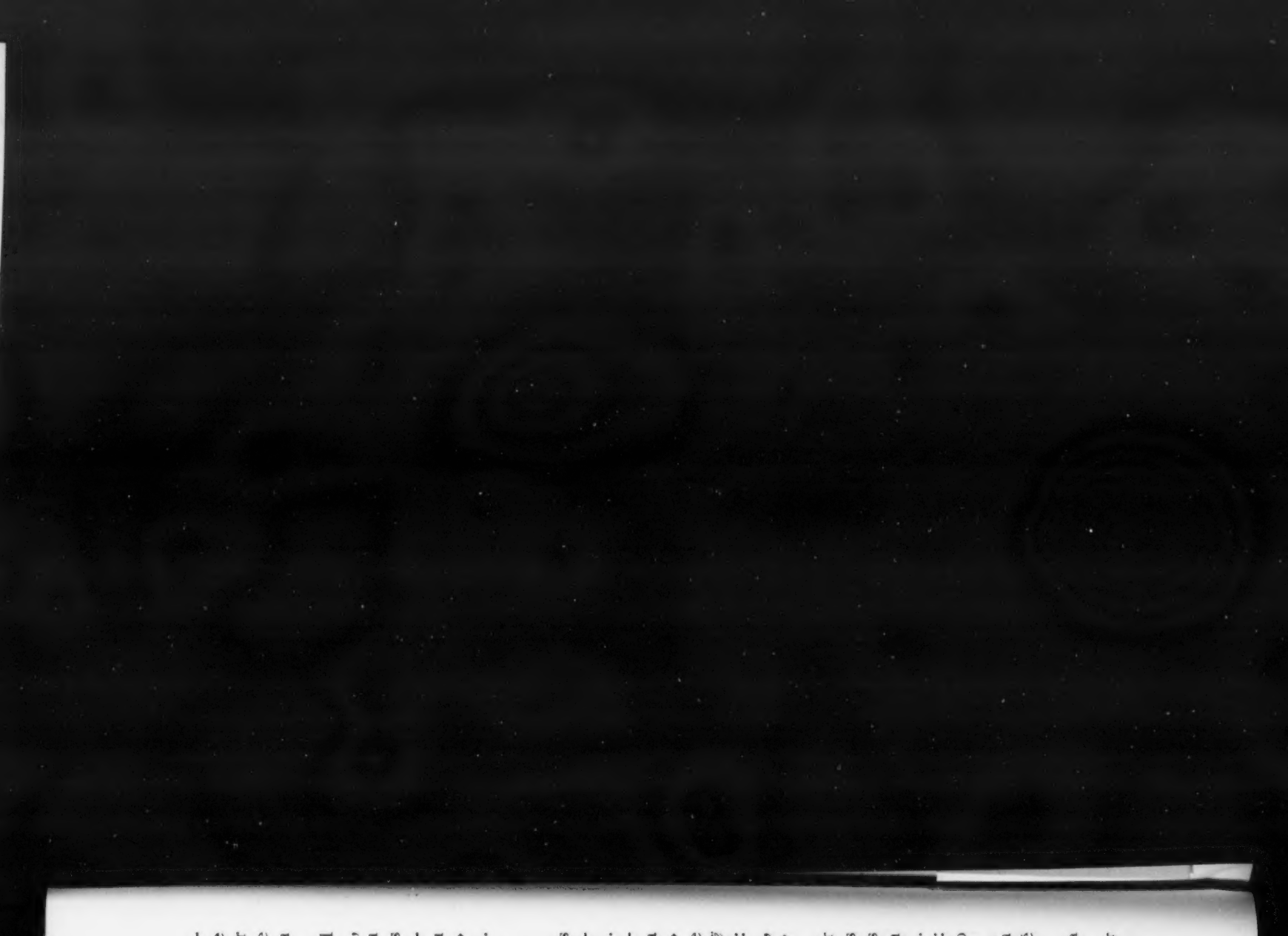
Cultivadas as plantas exactamente nas mesmas condições de meio, verificamos a existência de 5 *formas* (A-E) diferentes da *forma* «mãe do clone» (N) (v. fig. 3-4).

Essas diferenças são bem patentes nas caracteristicas gerais da flor (fig. 4): comprimento e largura das sépalas e das pétalas, tamanho relativo das partes próximais e distais do cálice e da corola (principalmente tubo e lábios da corola) e côr das pétalas. As flores são sempre vermelhas, mas mostram *nuances* do vermelho nìtidamente diferentes dumas formas para as outras. As folhas mostram-se também diferentes dumas formas para as outras: tonalidade diferentes do verde, recortes da margem, tamanhos relativos do peciolo e do limbo (fig. 3).

Não sabemos ainda o número «zigótico de cromosomas» de cada uma destas formas (CATARINO in prep.). Pelos aspectos morfológicos das plantas é

(1) Neste caso o novo indivíduo só regenera raízes, todos ou outros orgãos da nova planta já estam no brotos ou ramo que se utiliza como estaca.

(2) Não é também impossível que qualquer dos tipos de mutações se possa produzir anormalmente pelo agente físico ou químico que origina o calo.



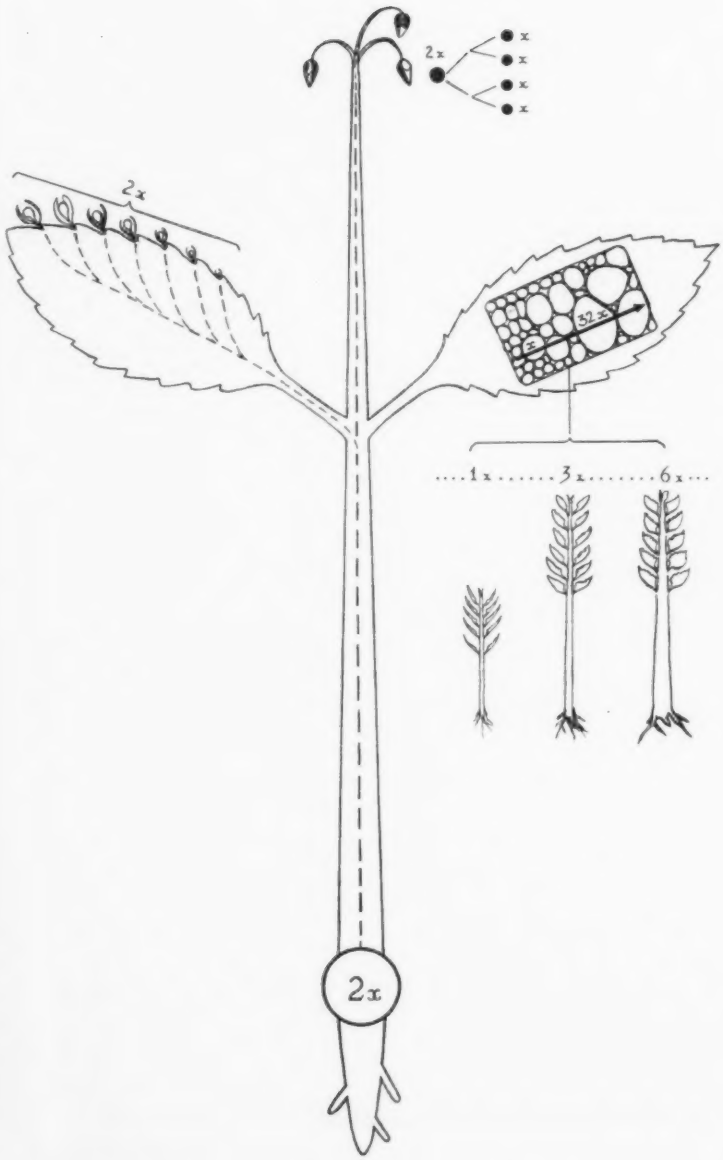


Fig. 1 *a*

Fig. 1 – Represent

Em cada um dos membros da série representa-se a *linha germinal* (l. g.) em linha tracejada ao longo do caule, flores e
variação cromosómica entre valores *x* e
Admite-se no esquema que o valor máximo de endopoliploidia é proporcional ao número zigótico e assim se *admite* 48 *x*
bilidade de formação apomictica de vários graus ploides (linha pu

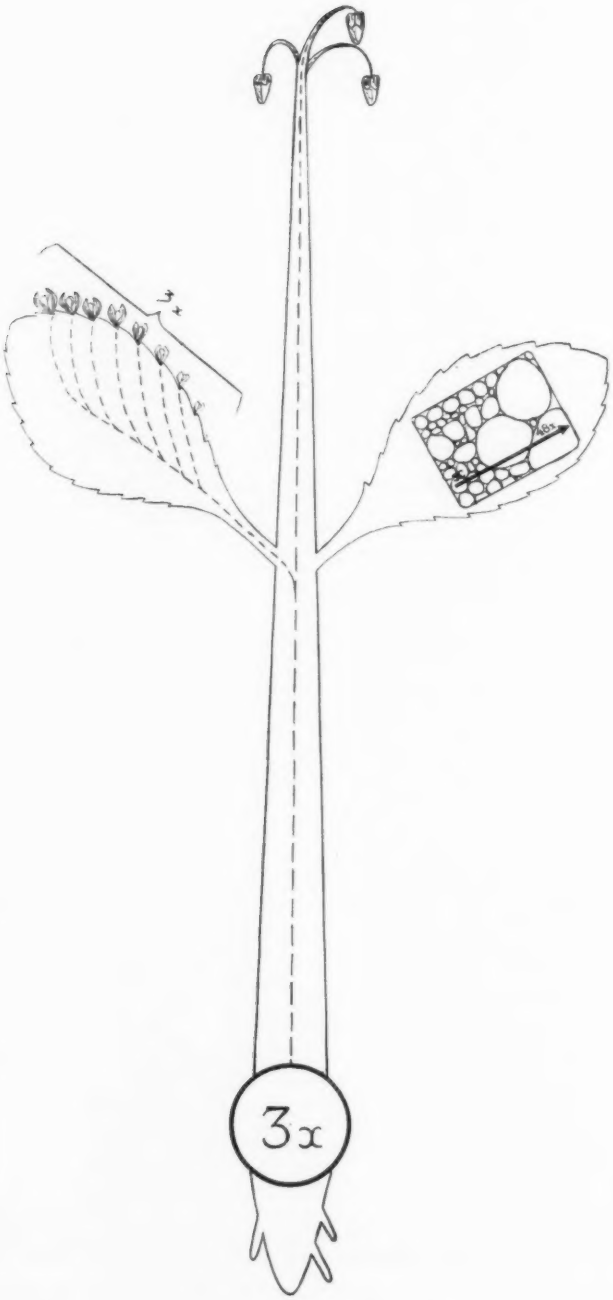


Fig. 1 *b*

Fig. 1 – Representação semi-esquemática duma série poliploide (2 *x*, 3 *x*, 4 *x*) em *Kalanchoideae* em geral.
o do caule, flores e folhas. A l. g. forma esporos e gametas com *n* (número gamético) e pseudo-bolbilhos com 2 *n* (
a entre valores *x* e 32 *x*, (este último foi o valor máximo encontrado por v. Witsch & Flügel em *Kal. blossfeldiana*
ssim se *admite* 48 *x* e 64 *x* para valores máximos dos graus zigóticos 3 *x* e 4 *x* (fig. *b*, *c*); para valores minimos admit
ploides (linha punctoada abaixo da folha direita) dos quais se representam 3 jovens plantas, uma de grau ploide a

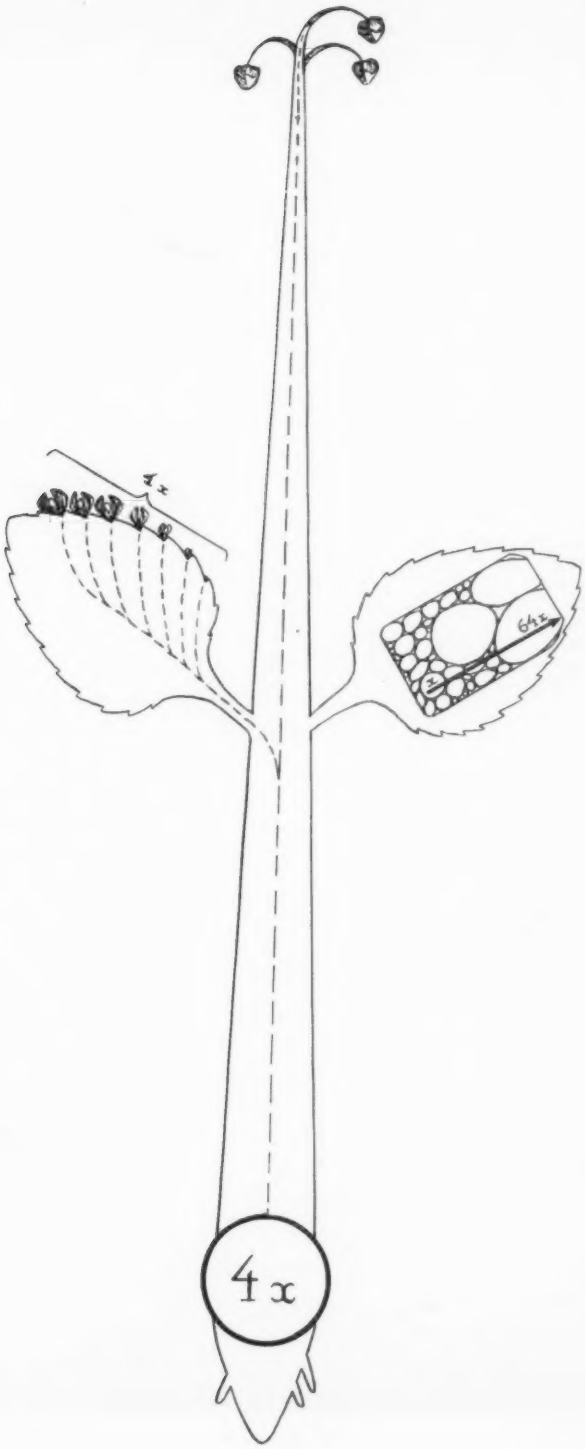
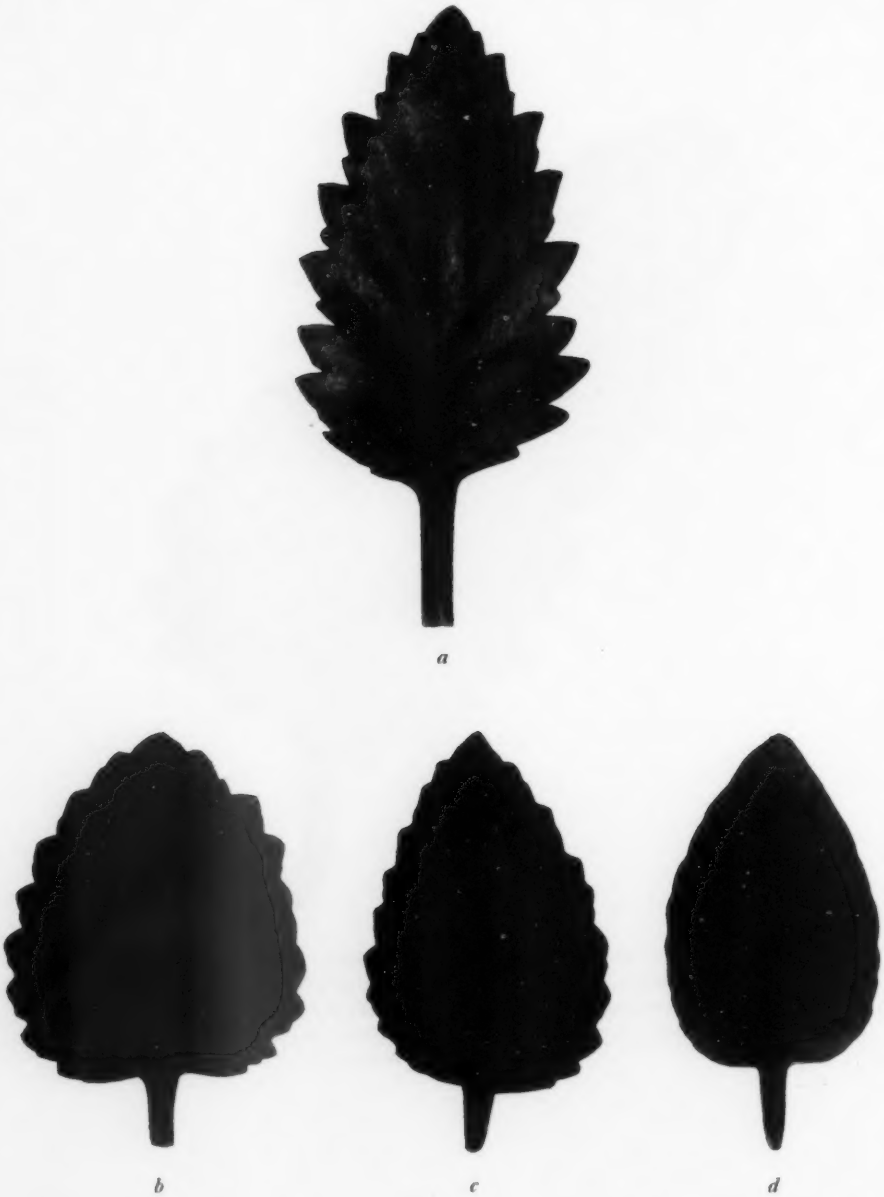


Fig. 1 *c*

s com 2 *n* (número zigótico). No parenquima da folha representa-se, para o grau diploide (2*x*), uma *sfeldiana* v. P.).

mos admite-se o mesmo em todos os graus zigóticos. No esquema *a* representa-se também a possi- u ploide abaixo do zigótico e 2 de grau superior.

Fig. 2 — × *Bryokalanchoë lisbonensis*: folha fendida (seta) e regenerando, no vértice da fenda, um calo inicial para 1 ou mais plantas já com um sistema radicular muito desenvolvido. Estes calos formam sempre, neste híbrido, primeiro raízes e depois caule e ramos.



a

b *c* *d*

Fig. 3 – × *Bryokalanchoë lisbonensis:* folhas da mesma posição a partir do vértice (4.º par): *a*) cabeça de clone (forma N); *b*) forma A; *c*) forma C; *d*) forma D. ×1.

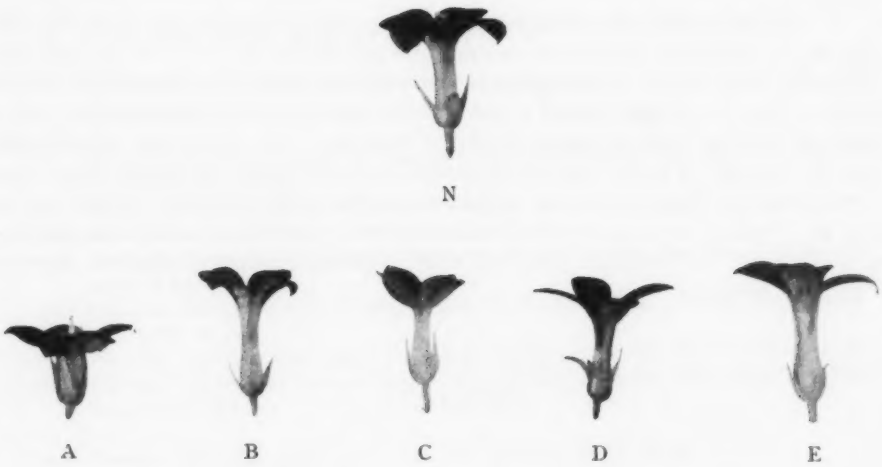


Fig. 4 – × *Bryokalanchoë lisbonensis*: N, flor da forma cabeça de clone.
A - E, flores das 5 formas aberrantes.

de prever que a forma *A* tenha um número zigótico de grau poliploide duplo ou ainda superior ao grau poliploide da *forma N.* Talvez algumas das outras formas ou todas, e principalmente a forma *C*, mostrem um grau poliploide inferior ao grau da forma *N.* A verificar-se esta previsão teremos, na forma-mãe (N), maior frequência somática de reduções cromosómicas (hipoploidização, VAARAMA, HUSKINS, RESENDE 1951, 1956a, 1957, WARDEN 1958 fig. 1 *b*) do que de hiper-poliploidização. Pode tratar-se também de mutações estructurais (v. a.).

Em *Kalanchoë blossfeldiana* conhece-se nos parenquimas da folha uma variação cromosómica somática enorme que vai de $2x$-$32x$ ($x = 17$) (v. WITSCH & FLÜGEL 1951, 1952). Estes autores não referem números aneuploides nesta espécie. Como $\times$ *Bryokalanchoë* é um hibrido intergenérico estéril, é de supor a existência de um metabolismo somático anormal com frequente aglutinação cromática e endo- e exomitoses originando frequentemente números irregulares de cromosomas. Serão também algumas plantas originadas em tecidos portadores de células mutadas estructuralmente em consequência daquele metabolismo aberrante? É também possível, e até bastante provável, dado o aspecto das formas B-E.

RESUMO

Num clone, feito por regeneração de folhas, (fig. 2) em *Bryophyllum lisbonensis*, obtiveram-se 31 % de plantas genèticamente diferentes da planta cabeça de clone (fig. 3).

A origem destas plantas é atribuída à grande variação somática de números de cromosomas, conhecida já como existindo frequentemente nos parenquimas das suculentas e principalmente de *Bryophyllum e Kalanchoë*, pais do hibrido aqui estudado.

SUMMARY

In a leaf propagated clone (fig. 2) of $\times$ *Bryokalanchoë lisbonensis*, 31 % of the plants obtained were genetically different from the clone head (fig. 3-4).

The aberrant plants may have their origin in somatic cells with chromosome sets differing from that of the zygote of the clone mother (= clone head) (cf. fig. 1). A great somatic variation of chromosome number is already known to occur in the parenchyma of suculents, especially in *Bryophyllum* and *Kalanchoë*, parents of $\times$ *Bryokalanchoë.*

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NOTICIÁRIO

Getreide-Umwandlung und Artproblem. — *(Transmutação dos Cereais e o Problema da Espécie) por* MAURITZ DITTRICH *Veb. Gustav Fischer Verlag) Jena,* 1959, 218 págs. - DM. 20.15)

É este um livro magnifico para tantos apaixonados! Neste livro mostra-se, atravez de calma investigação histórica, como todo o chamado LYSENKISMO que tão grande celeuma levantou, nada tem de original.

A afirmação de que existe transformação das espécies uteis, principalmente cereais, umas nas outras e em ervas daninhas e vice-versa, é coisa antiga:

Desde ARISTOTELES até nós existem ligadas entre si «umbilicalmente» as afirmações, ou melhor as crenças populares, da *Transmutação das espécies* e da *geração espontanea.*

O autor faz a história desta «superstição» popular, no que respeita a *Transmutatio* desde HERAKLITO até LYSENKO, mostrando atravez dos séculos as épocas de maior e as de menor «penetrância» destas «crenças» nos chamados meios cultos, tanto filosóficos como científicos.

Estes últimos 20 anos foram uma época de ± 100% penetrância na Russia.

O «surto» tende actualmente a desaparecer por completo, deixando atraz de si qualquer coisa de positivo: o estimulo para experimentação em massa levada principalmente a cabo na Alemanha oriental (cf. H. STUBBE).

«Não há de facto nada tão mau que não traga qualquer coisa de bom».

F. RESENDE
(Lisboa)

Papierchromatographie in der Botanik. — *(A cromotografia de papel na botânica)* — *Publicado por* H. F. LINSKENS — 2.ª edição — *Springer-Verlag, Heidelberg,* 1959, 408 págs. DM 58.

Este livro, publicado por H. F. LINSKENS com colaboração de 23 especialistas, sai agora na sua 2.ª edição, passados apenas 4 anos da primeira. Os rápidos progressos da cromatografia e a crescente importância deste método em botânica deram a esta edição o dobro do volume. O livro representa um manual exce-

lente, onde se encontra, para trabalho analítico, tanto técnicas simples para cada tipo de constituintes, como boas tabelas e bibliografia. Inicialmente há uma parte geral e depois capítulos sobre catiões e aniões inorgânicos, fosfatidos e lipidos, proteínas e enzimas e seus constituintes, ácidos nucleicos e seus constituintes, vírus das plantas, pigmentos, auxinas e vitaminas, substâncias antibióticas e toxinas, aldehidos e acetonas, compostos fenólicos, bases orgânicas inclusive alcalóides, esterinas e compostos relativos. A fechar o livro há uma terminologia técnica muito útil em 3 línguas.

M. Brinckmann
(z. Z. in Lissabon)

Netter, Hans: *Theoretische Biochemie. Physikalisch-chemische Grundlagen der Lebensvorgänge.* 816 p. e numerosas tabelas e figuras. Springer-Verlag, Heidelberg. (88 DM) 1959. (Bioquímica teórica. Bases físico-químicas dos processos vitais).

O conteúdo deste vasto livro corresponde talvez mais ao subtítulo do que ao título. Aliás, é difícil circunscrever o que deveria ser a Bioquímica Teórica, tanto mais que o âmbito da própria Bioquímica em geral, é também de imprecisos limites em relação à restante Química e à Química-Física. Neste livro o Prof. Netter, professor de Química Fisiológica na Universidade de Kiel, trata principalmente dos fundamentos teóricos da Química-Física na parte que desta interessa à Biologia. As aplicações pròpriamente, dizem respeito tanto àquilo que noutros países se costuma designar por Biofísica, como à Bioquímica. Um dos maiores interesses das matérias tratadas em livros como este, está justamente em ficarem nas fronteiras entre várias disciplinas que o desenvolvimento didáctico foi artificialmente separando, mas que a natureza não respeita.

Uma resenha dos assuntos tratados elucidará melhor o leitor sobre o conteúdo do livro. São tratados, numa 1.ª parte, que o autor designa por «Estática»: 1. Partículas e forças em dimensões moleculares, com breve exposição da estrutura atómica, valência e ligações químicas, e forças de coesão e mecanismos das reacções. 2. Água, difusão e osmose, sendo tratados também os fundamentos da repartição de água nos tecidos e a osmoregulação. 3. Electrólitos, com o usual estudo da dissociação, pH e solubilidade. 4. Fases e interfases, onde são tratados a lei de fases de Gibbs, forças de interfases, emulsões, adsorção, equilíbrio Donan e fenómenos similares. 5. Compostos estruturais de macromoléculas, com estudo do comportamento osmótico, reológico e óptico das macromoléculas, viscosidade, hidratação e entumescimento, assim como a estrutura básica das proteínas e ácidos nucleicos, sistemas com lipóides, sistemas coloidais e estrutura protoplásmica.

Na 2.ª parte, designada «Dinâmica», são estudados: 6. Bases energéti-

cas das reacções e processos bioquímicos, enthalpia, calores atómico e molecular e transformações de fase, entropia e suas alterações em relação aos processos vitais, equilíbrios móveis e outros, com aplicações a algumas das mais usuais reacções bioquímicas. 7. Bases físicas das oxidações biológicas, medidas do transporte de electrões, potencial redox, oxidações biológicas e radicais transitórios, polarografia. 8. Emprego e produção biológicos da energia química livre, reacções produtoras de energia livre, em particular dos hidratos de carbono, ligações portadoras de energia, energética dos processos de assimilação, foto-síntese, e formação dos compostos estruturais. 9. Regulação de velocidade das reacções bioquímicas, com exposição dos princípios sobre velocidades de reacções de várias ordens, cinética das transformações de compostos marcadores (tracers), energia e «steady-state», calores de activação e termodinâmica de reacções de activação, catalizadores e enzimas e leis da sua acção, condições e mecanismos das reacções enzimáticas, alguns tipos mais gerais de grupos enzimáticos, condutores de electrões, semicondutores, trocadores, e modelos de catalizadores.

Num «Capítulo final» são tratadas, sob o título geral de «Unidades estruturais e dinâmicas», diversas aplicações biológicas consideradas, quando possível, na estrutura fina e função conjuntamente. Em seguida à termodinâmica de sistemas estacionários e em fluxo constante, assim como de sistemas abertos, são brevemente estudadas aplicações às estruturas biológicas, concentração, transporte de hidrogénio e sistema ATP/ADP, assim como outras aplicações ao crescimento, respiração, fermentação, regulação osmótica e membranas, permeação e transporte activo, difusão catalítica e transportadores (carriers), «bombas» redox e trocas iónicas, metabolismo e secreção.

Com um conteúdo tão vasto, é evidente que muitos dos assuntos terão que ter sido tratados sumàriamente, apesar das 816 páginas do livro, incluindo Bibliografia e índice. Por outro lado, naturalmente que o autor não poderia estar informado em todos os assuntos com igual profundidade. Algumas aplicações biológicas não poderiam fugir às usuais simplificações, aliás quase inevitáveis em vista da dificuldade de explicar estruturas e fenómenos tão complexos em termos físico-químicos. Algumas omissões de desenvolvimentos modernos se poderiam notar. Por exemplo, a estrutura monomérica das proteínas e o dobramento dos àcidos nucleicos não são sequer mencionados.

Mas estes são menores senões. Em conclusão, o livro, bem editado pela Casa Springer, merece ser recomendado, pois prestará excelentes serviços aos biologistas e aos médicos que queiram passar do meramente descritivo e grosseiramente morfológico, ou do meramente profissional — à fisiologia e causalidade dos fenómenos biológicos. Para tais biologistas e médicos o livro fornecerá seguras e amplas bases químico-físicas.

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REVISTA DE BIOLOGIA

A *Revista de Biologia* é uma revista internacional que aceita, para publicação, trabalhos, cujo conteúdo represente progresso na resolução de problemas respeitantes a qualquer ramo da biologia. Trabalhos de compilação só poderão ser aceites se apresentarem pontos de vista novos, ou contribuírem pelo seu aspecto crítico (mas nunca polémico), para o estímulo da investigação.

Só excepcionalmente serão aceites trabalhos contendo mais do que 50 páginas, incluíndo figuras. As figuras serão limitadas ao mínimo indispensável. Todos os Autores do Ultramar devem reter cópia do manuscrito. As provas são enviadas por avião não acompanhadas do original, que será remetido junto com as separatas.

O Autor, ou Autores, de cada trabalho recebem 50 exemplares grátis. Emendas feitas nas provas, além dos erros tipográficos, serão onerados aos Autores.

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Para a secção *Noticiário* aceitam-se de bom grado críticas de livros e principalmente de grupos de trabalhos, cuja articulação em conjunto contribua para a clareza na compreensão dos problemas em causa, auxiliando assim a sua resolução. Referência sucinta a acontecimentos (viagens, descobertas, falecimentos, etc.), que interessam à biologia serão também insertos nesta secção.

* * *

This is an international journal publishing work in any branch of the biological sciences. Reviews will only be accepted if they present a new approach or may stimulate further research by their critical (but not controversial) nature.

As a rule, papers should not exceed 50 pages, including plates, and these must be reduced to a minimum.

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Manuscripts submitted to the editors may be subject to alterations before being accepted for publication.

The section of *notices* will gladly accept reviews on books and especially on groups of related papers whose combined results provide a clearer insight of the problem under review. Brief notes on expeditions, discoveries, etc. of biological interest may also be included in this section.

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